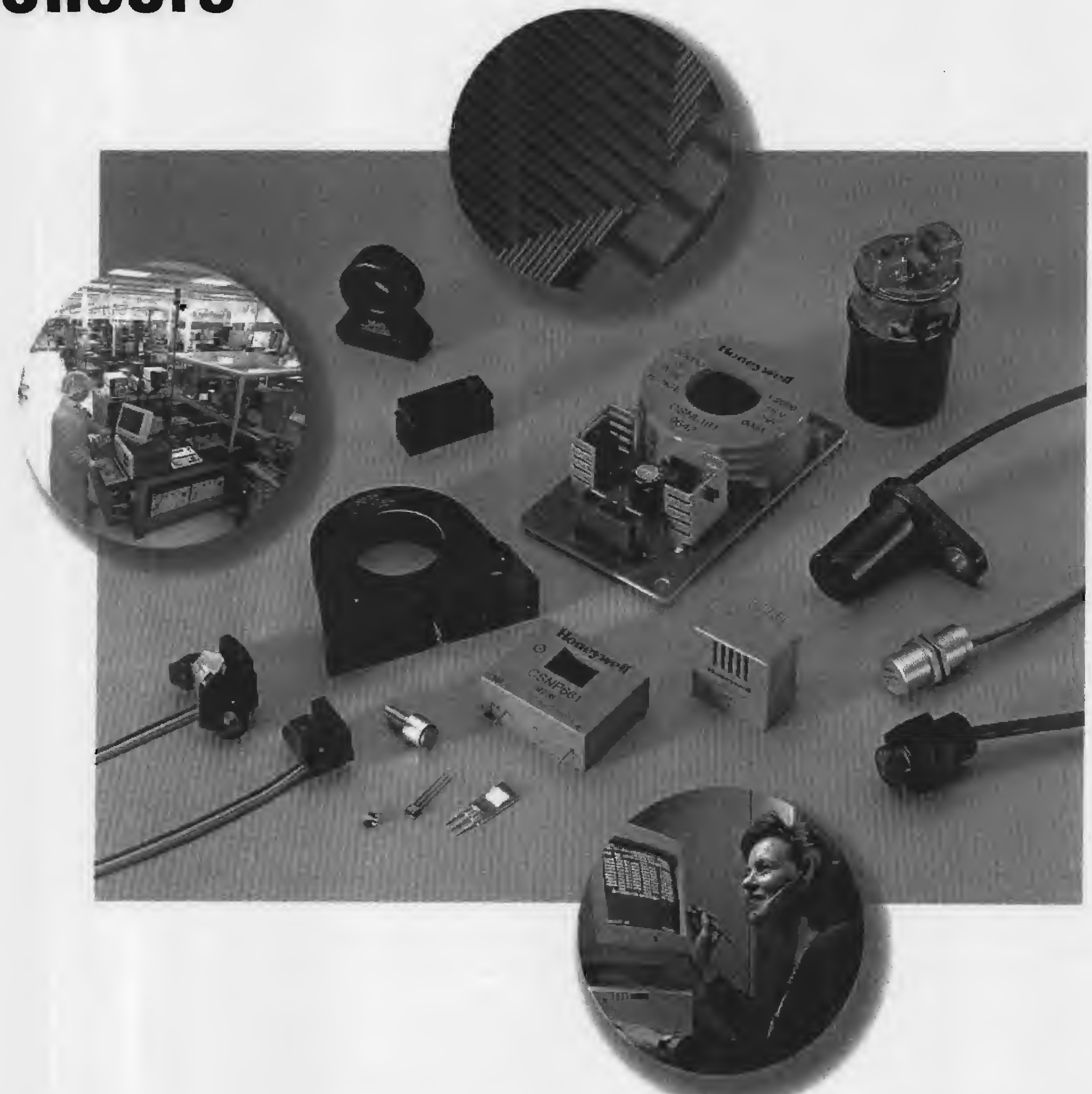
Honeywell

MICRO SWITCH
Sensing and Control

October 1997

Solid State Sensors

Catalog 20



This information available on CD-ROM and the World Wide Web!

How to Use This Catalog

CATALOG PURPOSE
This catalog is intended to familiarize users with the broad MICRO SWITCH product offering and provide ordering information for the most popular listings.

The products described on the following pages are representative of the thousands of position and current sensors manufactured and distributed by MICRO SWITCH. Almost all of the catalog listings given are preferred listings and normally will be off-the-shelf delivery.

USING THE CATALOG
This page will help you make a logical choice in selecting the best product for a particular application need. It allows a user familiar with our products to quickly locate the exact page the needed product catalog listings are on. For those unfamiliar with MICRO SWITCH products, a logical sequence is given to help the user pick the appropriate product for the application need.

By taking a few minutes to familiarize yourself with the catalog organization, you will find it very easy and will quickly locate the product you need.

REFERENCE DATA
Need reference and application information - (See page 78).

Definitions of terms will familiarize you with terminology used throughout the catalog (Page 119).

MOUNTING DIMENSIONS
Mounting dimensions are shown for each product in English and metric equivalents. These dimensions are for reference only. For exacting layout work, request an engineering drawing from the 800 number.

Many of the most popular Hall effect position sensors and current sensors are included in the catalog. Many others, developed for special needs, are not. For more information or prices, contact a MICRO SWITCH Sales Office or your local MICRO SWITCH Authorized Distributor or call 1-800-537-6945.

SELECTION
On page 1 you can see representative products found in the catalog. The various sensor types and offerings are highlighted below. The Table of Contents directs users to the main parts of the catalog.

1. SS94A2C
If you have a catalog listing, use the alphanumeric index-page number guide starting on page 124.

2. ANALOG POSITION SENSORS
If you know the type of sensor you are looking for, use the Table of Contents to find the page number.

⚠WARNING

MISUSE OF DOCUMENTATION

- The information presented in this catalog is for reference only. DO NOT USE this document as product installation information.
- Complete installation, operation and maintenance information is to be referenced for each product.

Failure to comply with these instructions could result in serious injury.

3. USE SELECTION GUIDE
If you're not familiar with the products or need more information, a detailed selection guide begins on page 4. Here photos for each product type and important selection factors are given to help determine and select the best product for the application.

- Physical description - size, construction, etc.
- Temperature ranges, operating gauss, etc.
- Electrical parameters - supply, output, etc.
- Termination - PCB, leadwires, etc.
- Output type - sinking, sourcing, etc.

In many cases, more than one product may work. For the most cost-effective solution, compare prices and consider alternatives. Remember, end cost includes initial product price, plus installation, plus service.

Solid State Sensors

Selection

MAGNETIC SENSORS
Hall effect position sensors produce either digital or analog outputs. There are three types of digital sensors: bipolar, omnipolar and unipolar. Analog sensors operate by proximity to either magnetic pole. Digital and analog sensor only devices are operated by the magnetic field from a permanent magnet or electromagnet. Actuation mode depends on the type of magnets used. Integral magnet position sensors are operated by either a vane passing through a gap, or a magnet mounted on a plastic plunger.

CURRENT SENSORS
Current sensors monitor AC or DC current. Included are adjustable linear, null balance, digital and linear current sensors.

TEMPERATURE SENSORS
Temperature sensors contain a silicon chip with a thin film resistive network pattern. The chips are individually laser trimmed to provide 2000 ohms resistance at room temperature.

⚠WARNING

PERSONAL INJURY

- DO NOT USE these products as safety or emergency stop devices, or in any other application where failure of the product could result in personal injury.

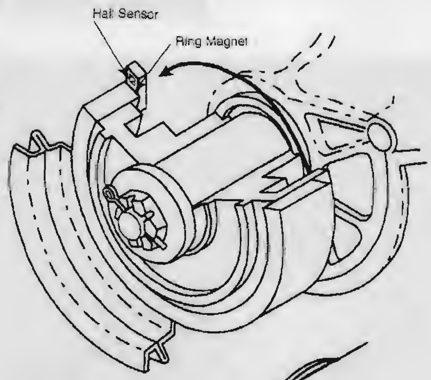
Failure to comply with these instructions could result in serious injury.

NOTE:
Before placing an order, please check the date on the front of this catalog. If it's more than a year old, we may have a more up-to-date catalog available.

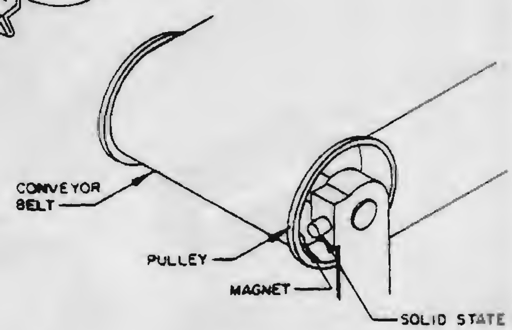
To assure you have the latest information on our product offering, call the MICRO SWITCH Application Center at 1-800-537-6945. They can tell you if your catalog is current, and they'll be happy to send you a new one if it's not. They'll also help immediately to confirm the validity of the product listing you'd like to order.

Typical Applications

Position Sensors
Position sensors are used in applications which require accurate, reliable outputs. They are found in brushless DC motors, utility meters, welding equipment, vending machines, home appliances, computers, etc.

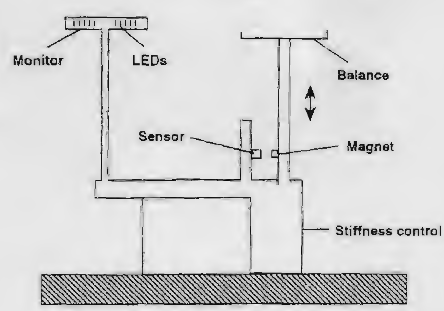


TYPICAL APPLICATIONS
Ignition timing
Power sensing
Valve position
Robotics control
Current sensing
Linear or rotary motion detection
Length measurement
Flow sensing
RPM sensing
Security systems



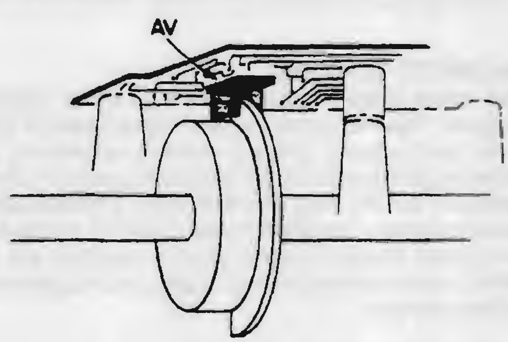
Integral Magnet Position Sensors
MICRO SWITCH combines digital Hall effect sensors with integral magnets to produce mechanically operated solid state sensors and vane sensors.

TYPICAL APPLICATIONS
Ignition timing
Valve position
Linear or rotary motion detection
Length measurement
RPM sensing
Security systems



Current Sensors
Current sensors monitor current flow.

TYPICAL APPLICATIONS
Variable speed motor controls
Automotive diagnostics (battery drain detector)
Electronic circuits - semiconductor protection
Welding power supplies
Uninterruptible power supplies



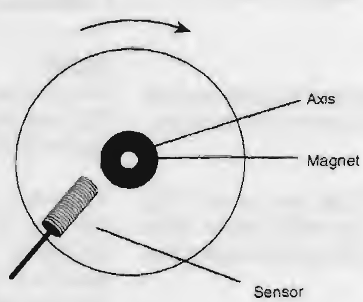


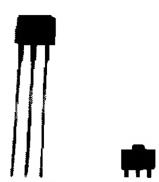
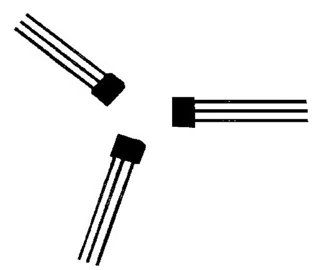
Table of Contents

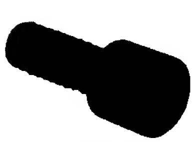
Selection

Solid State Sensors
Selection Guide

POSITION SENSORS

	 **2SSP** **Page 7**	 **SS400** **Page 8**	 **SS100/SS10** **Page 10/13**
Operation	Proximity to external magnet	Proximity to external magnet	Proximity to external magnet
Supply Voltage	6-24 VDC	3.8 to 24 VDC	3.8 to 30 VDC (SS100), 4.5-24 VDC (SS10)
Construction	Molded plastic package	Molded plastic package	Molded plastic package
Termination	Printed circuit board, Through-hole, or Surface mount	Printed circuit board, Through-hole or Surface mount	Surface mount, printed circuit board
Operating Speed	0 to over 100 kHz	0 to over 100 kHz	0 to over 100 kHz
Temperature Range	−20 to 85°C	−40 to 150°C	−40 to 125°C
Output Type	Digital, NPN	Digital, NPN	Digital, NPN

	 **SS41** **Page 12**	 **SS49/SS19** **Page 17**	 **SS490** **Page 20**
Operation	Proximity to external magnet	Proximity to external magnet	Proximity to external magnet
Supply Voltage	4.5-24 VDC	4-10 VDC	4.5-10.5 VDC
Construction	Molded plastic	Molded plastic	Molded plastic
Termination	Printed circuit board, Through-hole, or Surface mount	Printed circuit board, Through-hole, or Surface mount	Printed circuit board, Through-hole or Surface mount
Operating Speed	0 to over 100 kHz	1.5 μ seconds (Response)	3 μs typical (response)
Temperature Range	−55 to 150°C	−25 to 85°C	−40 to 150°C
Output Type	Digital, NPN	Analog, PNP	Analog, NPN or PNP



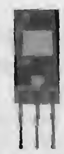
MG MAGNETS
Page 25

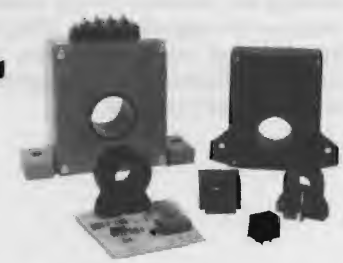
MICRO SWITCH supplies bar and ring magnets for operating our Hall effect sensors. These are provided in a wide variety of magnetic materials, sizes, shapes, and mounting options.

APMS-10G Turbidity Sensors
Page 27

The APMS-10G Wash Process Sensor provides an integrated package consisting of a microprocessor and three sensing functions.

Solid State Sensors
Selection Guide

			TEMPERATURE SENSORS
			
103SR **Page 14**	**SR3/SR4** **Page 15**	**SS94** **Page 18**	**TD/HEL Temperature** **Page 29**
Proximity to external magnet	Proximity to external magnet	Proximity to external magnet	Temperature changes
4.5-24 VDC	4.5-24 VDC	4.5-12 VDC	4-9 VDC
Threaded aluminum bushing	Thermoplastic housing	Ceramic hybrid circuit	Molded plastic package
Leadwires	Leadwires	Printed circuit board	Printed circuit board
0 to over 100 kHz	0 to over 100 kHz	3 μ seconds (response)	$\approx$ 1 to 4 seconds
-40 to 100°C	-40 to 85°C	-40 to 125°C	Depends on sensor
Digital, NPN or PNP Analog, PNP, pg. 24	Digital, NPN	Analog, NPN or PNP	Linear

MOISTURE SENSORS	BASIC SWITCH STYLE	GEAR TOOTH SENSOR	CURRENT SENSORS
			
HIH Moisture/Humidity **Page 41**	**VX** **Page 48**	**GT1** **Page 52**	**CS** **Page 54**
Humidity/moisture changes	Mechanical plunger	Ferrous metal	Current sensor
4-9 VDC	4.5-24 VDC	4.5-24 VDC	Depends on sensor
Ceramic hybrid circuit	Plastic housing	Plastic housing	Plastic housing
Printed circuit board Surface mount	Connector compatible	Leadwires	Screw, quick-connect or printed circuit board
$\approx$ 1 to 4 seconds	Depends on actuator	Depends on actuator speed	Depends on sensor
Depends on sensor	-40 to 70°C	-40 to 150°C	-25 to +85°C
Linear	Digital, NPN, N.O. or N.C.	Digital, NPN	Analog or digital

AV vane sensors change output state when a ferrous vane is passed thru the gap. Page 50.

Our solid state sensor products are not necessarily designed or manufactured for use as a "critical component" in a "critical device" as those terms are defined in the Medical Devices Subchapter contained in the Food & Drug Administration Rules, 21CFR 800.

Selection

Solid State Sensors
Position Sensors

FEATURES
- Magnetic sensing using Hall effect technology
- 3.8 to 30 volt supply voltages (SS400/SS100)
- Wide variety of package sizes
- Sensor only and combination magnet/sensor units
- Digital and analog outputs
- Solid state reliability

OPERATION
MICRO SWITCH solid state Hall effect position sensors produce either a digital or analog output. Digital output sensors are in one of two states — on or off. Analog sensors provide a continuous voltage output which increases with a strong magnetic field and decreases with a weak magnetic field.

There are three types of digital sensors, bipolar, omnipolar and unipolar. Bipolar sensors require positive gauss (south pole) to operate and negative gauss (north pole) to release. Omnipolar sensors operate with either the north or the south pole. Unipolar sensors require a single magnetic pole (south) to operate. Release is obtained by moving the south pole away from the sensor. Analog sensors operate by proximity to either magnetic pole. Digital and analog sensor only devices are operated by the magnetic field from a permanent magnet or an electromagnet. Actuation mode depends on the type of magnets used. Integral magnet supplied position sensors are mechanically operated by a magnet mounted on a plastic plunger.

DIGITAL POSITION SENSORS, GENERAL INFORMATION
Digital position sensors are available in a variety of packages: molded plastic, ceramic substrate and threaded cylindrical housings.

- 3 pin in-line plastic packages for printed circuit board mounting with a single output.
- 3 pin plastic packages for surface-mount assembly, identical to industry standard SOT-89 packages.
- Environmentally protected aluminum or plastic housings with color coded leadwires.

APPLICATION
Typical sensor applications include:
- Ignition timing
- Power sensing
- Valve position
- Robotics control
- Current sensing
- Linear or rotary motion detection
- Length measurement
- Flow sensing
- RPM sensing
- Security systems

Sensors are used in:
- Brushless DC motors
- Utility meters
- Water softeners
- Gasoline pumps
- Welding equipment
- Balance scales
- Interlocks
- Flowmeters
- Magnetic card readers
- Vending machines
- Home appliances
- Computer equipment
- Medical instruments
- Copy machines
- Laboratory equipment

DEFINITIONS
Current Sinking (NPN) — A transistor configuration where loads are normally connected between the output and a supply voltage. When the transistor is ON current flow is from the load into the transistor.

Current Sourcing (PNP) — A transistor configuration where loads are normally connected between the output and ground. When the transistor is ON current flow is from the transistor into the load.

Differential (Hall effect transducer) — The difference between the operate and release values of a Hall effect transducer.

Maximum Operate Point refers to the level of magnetic field which will insure the digital output transducer turns ON under any rated condition.

Minimum Release Point refers to the level of magnetic field that insures the transducer is turned OFF.

Magnetic gauss values are found in each order guide.

For magnet ordering information see page 25.

For absolute maximum ratings, see pages 75 and 76.

Solid State Sensors
Digital Position Sensors

FEATURES
- Low gauss operation can extend sensing distance to one inch or more, depending on magnet size
- Digital current sinking output
- Omnipolar – can be operated with either North or South magnetic pole
- Operating speed: 0 to over 100 kHz
- Small size: .18 x .18 inch
- 3-pin, in-line PC board terminals on .100-inch mounting centers
- Operating temperature range: –20° to 85°C (–4° to 185°F)
- Surface mount style available – 2SSP-S

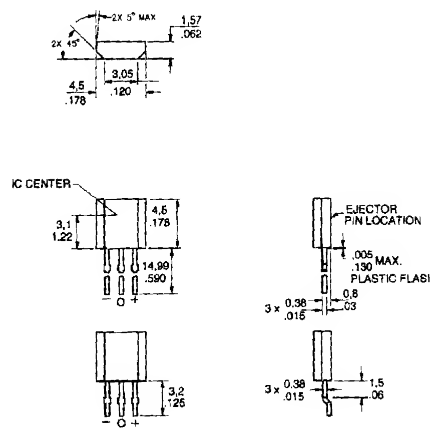
OPERATION
2SSP Series position sensors have magnetoresistive material integrated on silicon and encapsulated in a plastic package. The integrated circuit provides a digital output in response to very low magnetic fields. Though this signal is identical to our digital Hall effect sensors, it can be achieved by magnetoresistive sensors at much greater sensor-to-magnet distances. For example, the 2SSP sensing distance is approximately one inch, when operated by a MICRO SWITCH 101MG3 magnet.

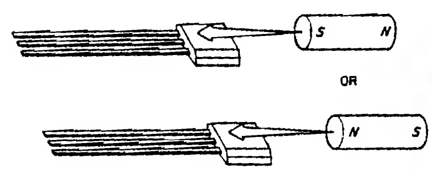
OPERATING MODE
(Arrows indicate direction of magnetic flux.)

2SSP sensors are operated by magnetic fields (North **or** South pole) **parallel** to the magnetoresistive element.

NOTE: Due to the inherent high sensitivity of 2SSP sensors, stray magnetic fields which are parallel to the IC may affect operation.

MOUNTING DIMENSIONS
(For reference only)





Digital

2SSP ORDER GUIDE

Catalog Listing			2SSP/2SSP-S	
Supply Voltage (VDC)			6 to 24	
Supply Current (mA max.)			13.5	
Output Type			Sink	
Output Voltage (V) @ 20mA			.40 max.	
Output Current (mA max.)			20	
Leakage Current (µA max.)			10	
Magnetics Type			Omnipolar	
Magnetic Char. & Temp.			Gauss	mT
	–20 to 85°C	Max. Op.	25	2.5
		Min. Rel.	5	0.5
		Max. Dif.	7	0.7
	25°C Typ.	Typ. Op.	15	1.5
		Typ. Rel.	11	1.1
		Typ. Dif.	4	0.4

Magnets page 25.
mT = milliTesla

FEATURES

- 3.8-30 VDC supply voltage
- Digital current sinking output
- 3 pin in-line PCB terminals
- Quad-Hall design virtually eliminates mechanical stress effects
- Temperature compensated magnetics
- Operate/release points can be customized
- Bipolar, unipolar, latching magnetics
- High output current capability –50 mA absolute maximum
- Operate/release points symmetrical around zero gauss (bipolar/latch)
- Operating temperature range of –40 to +150°C (–40 to +302°F)
- Package material: Plaskon 3300H
- Surface mount version available: SS400-S (with cut and formed leads)

SS400 Series position sensors have a thermally balanced integrated circuit over full temperature range. The negative compensation slope is optimized to match the negative temperature coefficient of lower cost magnets. Bipolar, latching and unipolar magnetics are available.

Band gap regulation provides extremely stable operation over 3.8 to 30 VDC supply voltage range. SS400 sensors are capable of continuous 20 mA sinking output, and may be cycled as high as 50 mA maximum.

NOTICE
Interruption of power to a latching device may cause the output to change state when power is restored. If a magnetic field of sufficient strength is present, the sensor output will be in the condition dictated by the magnetic field.

ORDER GUIDE

Catalog Listing		SS411A	SS413A	SS441A	SS443A	SS449A	SS461A	SS466A
Magnetic Type		Bipolar	Bipolar	Unipolar	Unipolar	Unipolar	Latching	Latching
Supply Voltage (VDC)		3.8 to 30	3.8 to 30	3.8 to 30	3.8 to 30	3.8 to 30	3.8 to 30	3.8 to 30
Supply Current (max.)		10 mA	10 mA	10 mA	10 mA	10 mA	10 mA	10 mA
Output Type		Sink	Sink	Sink	Sink	Sink	Sink	Sink
Output Voltage (max.)		.40 V	.40 V	.40 V	.40 V	.40 V	.40 V	.40 V
Output Current, max.*		20 mA	20 mA	20 mA	20 mA	20 mA	20 mA	20 mA
Output Leakage Current, max.		10 µA	10 µA	10 µA	10 µA	10 µA	10 µA	10 µA
Output Switching Time V_{cc}=12 V, R_L=1.6 K, C=20 pF	Rise (10-90%)	.05 µs typ. 1.5 µs max.	.05 µs typ. 1.5 µs max.	.05 µs typ. 1.5 µs max.	.05 µs typ. 1.5 µs max.	.05 µs typ. 1.5 µs max.	.05 µs typ. 1.5 µs max.	.05 µs typ. 1.5 µs max.
	Fall (90-10%)	.15 µs typ. 1.5 µs max.	.15 µs typ. 1.5 µs max.	.15 µs typ. 1.5 µs max.	.15 µs typ. 1.5 µs max.	.15 µs typ. 1.5 µs max.	.15 µs typ. 1.5 µs max.	.15 µs typ. 1.5 µs max.
Magnetic Characteristics		G mT	G mT	G mT	G mT	G mT	G mT	G mT
–40°C	Max. Op.	70 7.0	140 14.0	135 13.5	215 21.5	435 43.5	110 11.0	200 20.0
	Min. Rel.	–70 –7.0	–140 –14.0	20 2.0	80 8.0	210 21.0	–110 –11.0	–200 –20.0
	Min. Dif.	15 1.5	20 2.0	15 1.5	25 2.5	30 3.0	50 5.0	200 20.0
0°C	Max. Op.	65 6.5	140 14.0	117 11.7	190 19.0	400 40.0	90 9.0	185 18.5
	Min. Rel.	-65 -6.5	–140 –14.0	20 2.0	80 8.0	230 23.0	– 90 – 9.0	–185 –18.5
	Min. Dif.	15 1.5	20 2.0	18 1.8	25 2.5	30 3.0	50 5.0	200 20.0
25°C	Max. Op.	60 6.0	140 14.0	115 11.5	180 18.0	390 39.0	85 8.5	180 18.0
	Min. Rel.	–60 –6.0	–140 –14.0	20 2.0	75 7.5	235 23.5	– 85 – 8.5	–180 –18.0
	Min. Dif.	15 1.5	20 2.0	20 2.0	25 2.5	30 3.0	50 5.0	200 20.0
85°C	Max. Op.	60 6.0	140 14.0	120 12.0	180 18.0	400 40.0	85 8.5	180 18.0
	Min. Rel.	-60 -6.0	–140 –14.0	15 1.5	70 7.0	215 21.5	– 85 – 8.5	–180 –18.0
	Min. Dif.	12 1.2	20 2.0	15 1.5	15 1.5	30 3.0	50 5.0	190 19.0
125°C	Max. Op.	65 6.5	140 14.0	123 12.3	190 19.0	410 41.0	100 10.0	180 18.0
	Min. Rel.	-65 -6.5	–140 –14.0	15 1.5	60 6.0	200 20.0	–100 –10.0	–180 –18.0
	Min. Dif.	12 1.2	20 2.0	8 0.8	10 1.0	30 3.0	50 5.0	160 16.0
150°C	Max. Op.	70 7.0	140 14.0	125 12.5	200 20.0	420 42.0	110 11.0	185 18.5
	Min. Rel.	–70 –7.0	–140 –14.0	10 1.0	55 5.5	185 18.5	–110 –11.0	–185 –18.5
	Min. Dif.	10 1.0	20 2.0	5 0.5	5 0.5	30 3.0	50 5.0	140 14.0

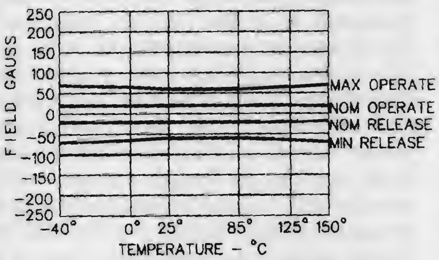
* Absolute maximum output current is 50 mA for all SS400 listings. G = Gauss. mT = milliTesla.

Note: For SS400 on tape with straight or formed leads on 0.100″ centers, contact the 800 number. One box contains 5,000 sensors.

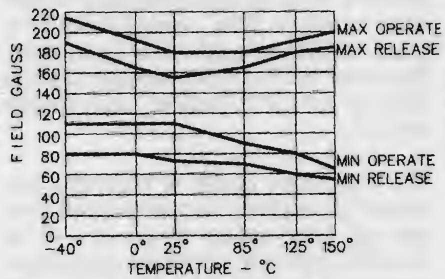
Solid State Sensors
Digital Position Sensors

OPERATE AND RELEASE POINTS

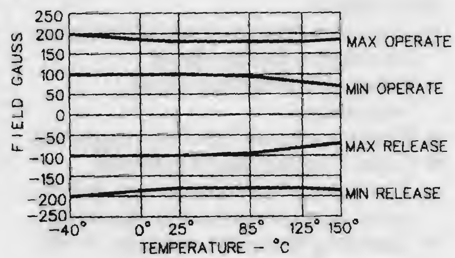
SS411A



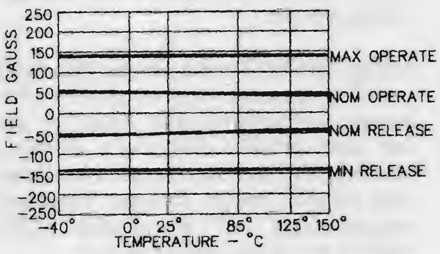
SS443A



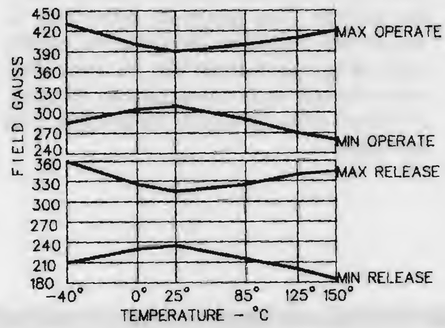
SS466A



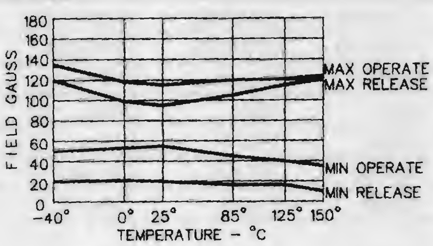
SS413A



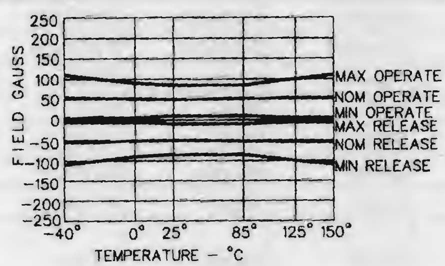
SS449A



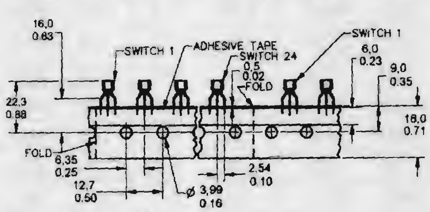
SS441A



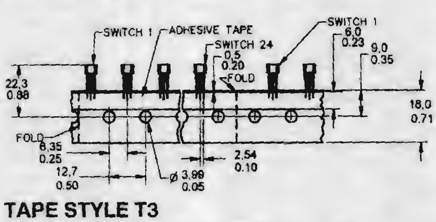
SS461A



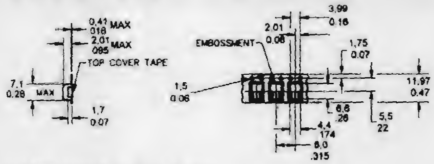
MOUNTING DIMENSIONS (For reference only)



TAPE STYLE T2

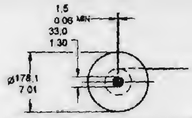


TAPE STYLE T3

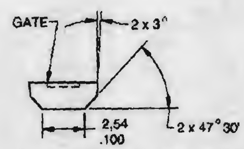


TAPE STYLE SP & RP

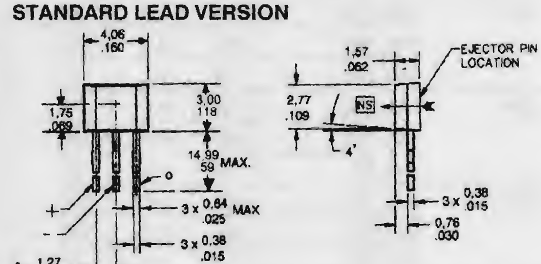
Tape styles T2 and T3 are supplied in Ammopack (Fanfold) format, in cardboard boxes. Each box contains 5000 sensors.



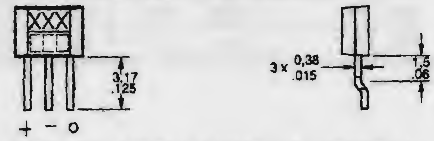
DIRECTION OF FEED FROM REEL



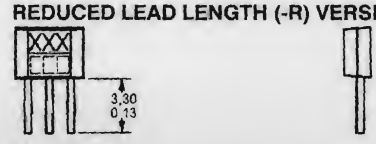
STANDARD LEAD VERSION



SURFACE MOUNT (-S) VERSION



REDUCED LEAD LENGTH (-R) VERSION



Solid State Sensors

Surface Mount Digital Position Sensors

FEATURES
- Quad Hall design virtually eliminates mechanical stress effects
- Temperature compensated magnetics
- Bipolar, unipolar, latching magnetics
- Super high sensitivity available
- Symmetry of operate/release points about zero gauss (bipolar/latching)
- Operating temperature range of –40 to +125°C
- Low current consumption (7 mA typical @ 5 V, 25°C)
- 3.8 to 30 VDC supply voltage range
- High output current capability of 50 mA absolute maximum

The temperature compensated Hall effect sensor consists of a quad Hall sensing element in a square integrated circuit chip, which is then encapsulated in a glass-filled thermoset molding material. The small SOT89 style package surface mounts on PC boards and flexible circuits.

The integrated circuit is thermally balanced for predictable performance over the full temperature range of –40 to +125°C. Built-in temperature compensation has a negative slope (operate and release points decrease as temperature increases). This slope is optimized to match the negative temperature coefficient of low cost magnets, to track their performance over temperature. Bipolar, unipolar and latching magnetics are available.

Band gap regulation provides extremely stable operation over the full supply voltage range of 3.8 to 30 VDC. Current consumption is a low 10 mA maximum. SS100 sensors are capable of continuous 20 mA sinking output, and can withstand temporary current as high as 50 mA absolute maximum. They can use existing power supply sources in most applications, and can be directly interfaced with many electronic components without buffering or compensation circuitry. SS100 Series sensors are available on tape and reel for high-volume, automated pick and place equipment. Each reel contains 1,000 sensors.

NOTE: DO NOT wave solder this product. This process may negatively affect sensor performance and reliability, and will void MICRO SWITCH's warranty. MICRO SWITCH recommends a convection infrared reflow process with peak temperatures not to exceed 220°C (428°F) for 10 seconds maximum.

ORDER GUIDE

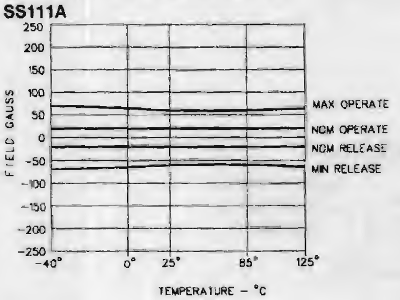
Catalog Listing	SS111A	SS113A	SS141A	SS143A	SS149A	SS161A	SS166A
Magnetic Type	Bipolar	Bipolar	Unipolar	Unipolar	Unipolar	Latching	Latching
Supply Voltage (VDC)	3.8 to 30	3.8 to 30	3.8 to 30	3.8 to 30	3.8 to 30	3.8 to 30	3.8 to 30
Supply Current (max.)	10 mA	10 mA	10 mA	10 mA	10 mA	10 mA	10 mA
Output Type	Sink	Sink	Sink	Sink	Sink	Sink	Sink
Output Voltage (max.)	.40 V	.40 V	.40 V	.40 V	.40 V	.40 V	.40 V
Output Current (max.)	20 mA	20 mA	20 mA	20 mA	20 mA	20 mA	20 mA
Leakage Current (max.)	10 µA	10 µA	10 µA	10 µA	10 µA	10 µA	10 µA
Output Switching Time Rise (10-90%) (max.) Fall (90-10%) (max.)	1.5 µs 1.5 µs	1.5 µs 1.5 µs	1.5 µs 1.5 µs	1.5 µs 1.5 µs	1.5 µs 1.5 µs	1.5 µs 1.5 µs	1.5 µs 1.5 µs

Magnetic Characteristics*		SS111A G	SS111A mT	SS113A G	SS113A mT	SS141A G	SS141A mT	SS143A G	SS143A mT	SS149A G	SS149A mT	SS161A G	SS161A mT	SS166A G	SS166A mT
–40°C	Max. Op.	70	7.0	140	14.0	135	13.5	215	21.5	440	44.0	110	11.0	200	20.0
	Min. Rel.	–70	–7.0	–140	–14.0	20	2.0	80	8.0	210	21.0	–110	–11.0	–200	–20.0
	Min. Dif.	15	1.5	20	2.0	15	1.5	25	2.5	30	3.0	50	5.0	200	20.0
0°C	Max. Op.	65	6.5	140	14.0	117	11.7	190	19.0	400	40.0	90	9.0	185	18.5
	Min. Rel.	–65	–6.5	–140	–14.0	20	2.0	80	8.0	230	23.0	– 90	– 9.0	–185	–18.5
	Min. Dif.	15	1.5	20	2.0	18	1.8	25	2.5	30	3.0	50	5.0	200	20.0
25°C	Max. Op.	60	6.0	140	14.0	115	11.5	180	18.0	390	39.0	85	8.5	180	18.0
	Min. Rel.	–60	–6.0	–140	–14.0	20	2.0	75	7.5	235	23.5	– 85	– 8.5	–180	–18.0
	Min. Dif.	15	1.5	20	2.0	20	2.0	25	2.5	30	3.0	50	5.0	200	20.0
85°C	Max. Op.	60	6.0	140	14.0	120	12.0	180	18.0	400	40.0	85	8.5	180	18.0
	Min. Rel.	–60	–6.0	–140	–14.0	15	1.5	70	7.0	215	21.5	– 85	– 8.5	–180	–18.0
	Min. Dif.	12	1.2	20	2.0	15	1.5	15	1.5	30	3.0	50	5.0	190	19.0
125°C	Max. Op.	65	6.5	140	14.0	123	12.3	190	19.0	410	41.0	100	10.0	180	18.0
	Min. Rel.	–65	–6.5	–140	–14.0	15	1.5	60	6.0	200	20.0	–100	–10.0	–180	–18.0
	Min. Dif.	12	1.2	20	2.0	8	0.8	10	1.0	30	3.0	50	5.0	160	16.0

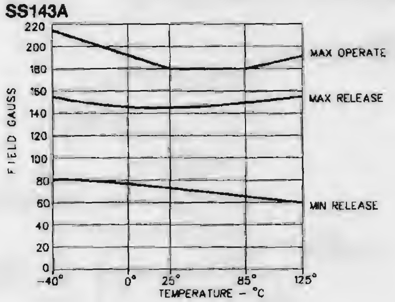
*G = Gauss
mT = milliTesla.

OPERATE AND RELEASE POINTS

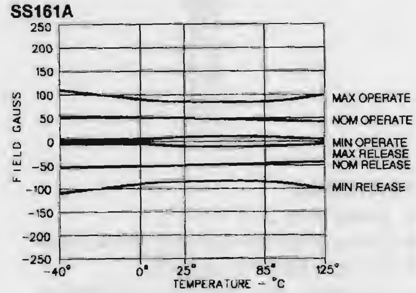
SS111A



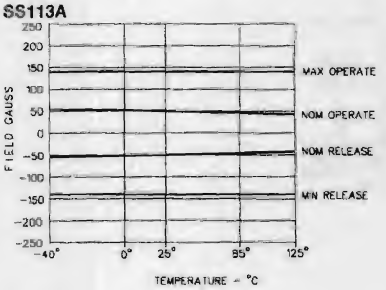
SS143A



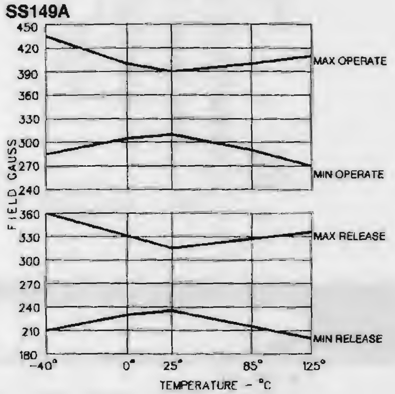
SS161A



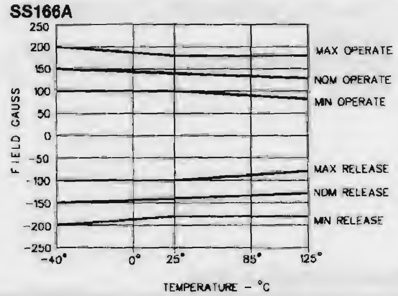
SS113A



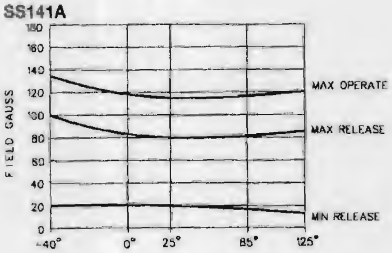
SS149A



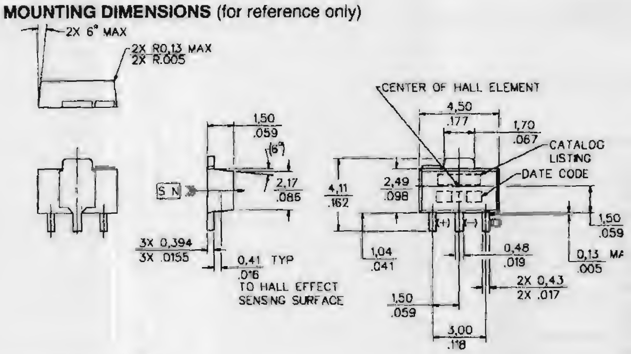
SS166A



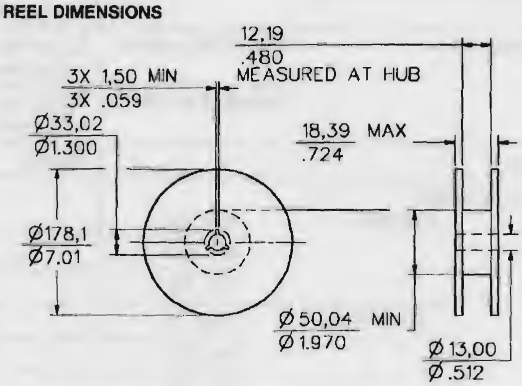
SS141A



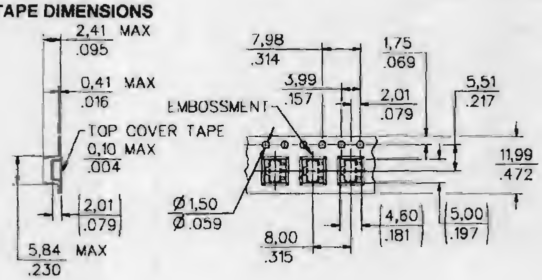
MOUNTING DIMENSIONS (for reference only)



REEL DIMENSIONS



TAPE DIMENSIONS



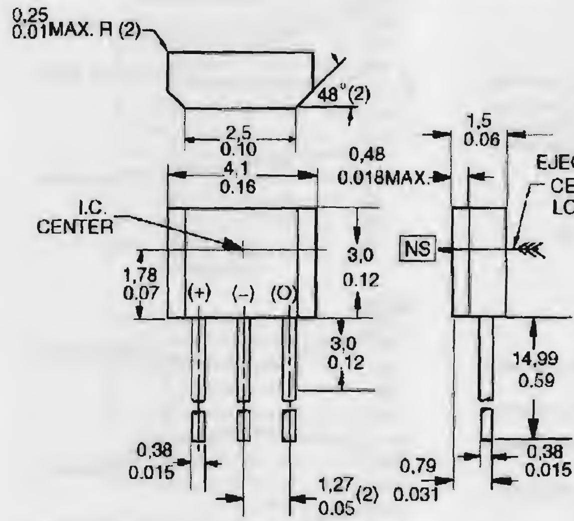
NOTICE

Interruption of power to a latching device may cause the output to change state when power is restored. If a magnetic field of sufficient strength is present, the sensor output will be in the condition dictated by the magnetic field.

Digital

Solid State Sensors
Digital Bipolar Position Sensors

MOUNTING DIMENSIONS (For reference only)



FEATURES

- Small size (.16" x .12")
- Reverse power polarity protection
- Current sinking output
- Sensitive magnetic characteristics
- Operating speed from 0 to over 100 kHz
- Operating temperature range: –55° to 150°C

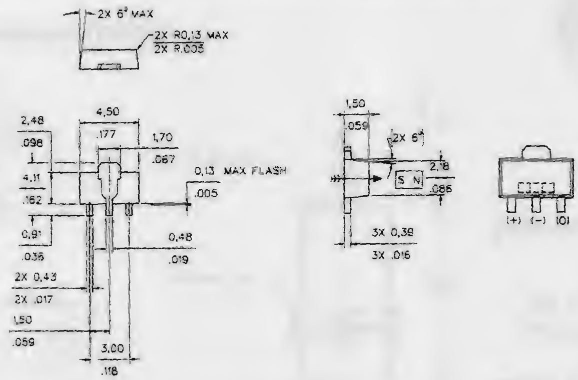
SS40 ORDER GUIDE

Catalog Listings			SS41	
Supply Voltage (VDC)			4.5 to 24	
Supply Current (mA)			4 typ., 8.7 max. @ Vs = 4.5V 6 typ., 15 max. @ Vs = 6 to 24V	
Output Type			Sink (20 mA max.)	
Output Voltage (V)			0.15 typ., 0.40 max. @ –40 to +125°C 0.15 typ., 0.45 max. @ 125 to 150°C	
Output Leakage Current (Released)			10 µA Leakage into sensor	
Output Switching Time		Rise (10% to 90%)	0.2 µs typ. 1.5 µs max.	
		Fall (90% to 10%)	0.5 µs typ. 1.0 µs max.	
Magnetic Type			Bipolar	
Magnetic Char. & Temp.*			G	mT
	0 to 85°C	Max. Op.	150	15.0
		Min. Rel.	–150	–15.0
		Min. Dif.	50	5.0
	–40 to 125°C	Max. Op.	200	20.0
		Min. Rel.	–200	–20.0
		Min. Dif.	40	4.0
	25°C Typ.	Typ. Op.	40	4.0
		Typ. Rel.	– 40	– 4.0
		Typ. Dif.	80	8.0
	–55 to 150°C	Max. Op.	250	25.0
		Min. Rel.	–250	–25.0
		Min. Dif.	30	3.0

*G = Gauss
mT = milliTesla.

FEATURES
- Small-size SOT89 style package (.177×.136×.059 in.) surface mounts on PC boards and flexible circuits
- Available in bulk or on tape and reel
- Reverse polarity protection
- Current sinking output
- Sensitive magnetic characteristics
- Compatible with pick-and-place equipment for automated assembly operations
- Operating speed: 0 to over 100 kHz

MOUNTING DIMENSIONS (For reference only)



SS11 sensors are available on tape and reel for high volume, automated pick and place equipment. Each reel contains 1,000 sensors.

NOTE: DO NOT wave solder this product. This process may negatively affect sensor performance and reliability, and will void MICRO SWITCH's warranty.

MICRO SWITCH recommends an infrared reflow process with peak temperatures not to exceed 200°C (392°F) for 10 seconds maximum.

SS1 ORDER GUIDE (Add "T" suffix to catalog listing for tape and reel as shown below.)

Catalog Listings	SS11 (SS11T)	
Magnetic Type	Bipolar	
Supply Voltage (VDC)	4.5 to 24	
Supply Current (mA)	4 typ. 8.7 max.	
Sinking Output (mA)	20 max.	
Output Voltage (V)	0.15 typ. 0.40 max.	
Output Leakage Current, Released (μA) (Leakage into sensor)	10	
Output Switching Time (μs) Rise (10% to 90%)	0.2 typ. 1.5 max.	
Fall (90% to 10%)	0.5 typ. 1.0 max.	
Magnetic Characteristics* @ 0 to 85°C, 32 to 185°F	G	mT
Max. Operate	150	15.0
Min. Release	−150	−15.0
Min. Differential	50	5.0
@ −40 to 125°C, −40 to 257°F Max. Operate	200	20.0
Min. Release	−200	−20.0
Min. Differential	40	4.0
@ 25°C, 77°F typ. Typ. Operate	40	4.0
Typ. Release	− 40	− 4.0
Typ. Differential	80	8.0

Magnets page 25.
*G = Gauss
mT = milliTesla.

APPLICATION INFORMATION

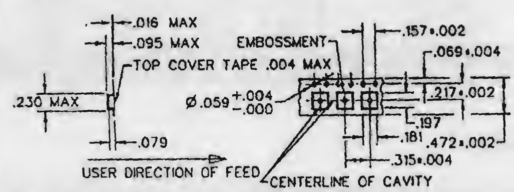
Operate/Release Characteristics Shift Over Temperature

SS11 Operate and Release vs. Temperature

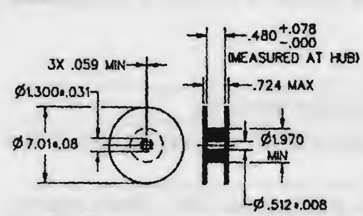
Wave soldering may negatively affect sensor performance.

TAPE AND REEL DIMENSIONS

Tape



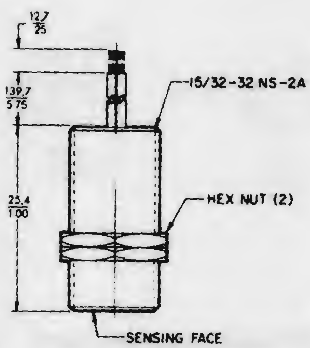
Reel



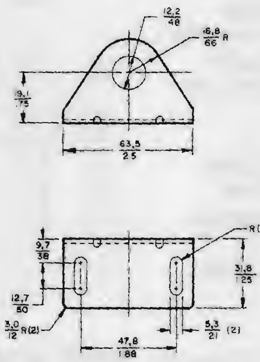
NOTE: One reel contains 1,000 sensors.

Digital

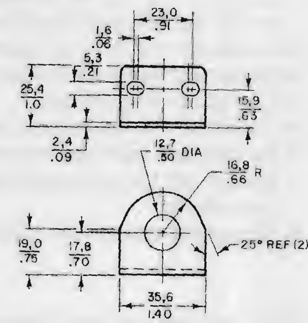
MOUNTING DIMENSIONS (For reference only)



1SR15 Mounting Bracket



1SR15HD Mounting Bracket



FEATURES
- Current sinking or current sourcing ouput
- Rugged, sealed threaded aluminum housing NEMA 3, 3R, 3S, 4, 12 and 13 requirements**
- 20 gauge, 6 inch stranded leadwires, color coded, or 1 meter jacketed cable
- Adjustable mounting

NOTE: For analog sensors, see page 24.

Leadwire color code:

Red	Vs (+)
Black	Ground (–)
Blue, Green, or White	Output

103SR ORDER GUIDE

Catalog Listings*		103SR11A-1		103SR12A-1		103SR13A-1		103SR14A-1		103SR17A-1		103SR18-1	
Supply Voltage (VDC)		4.5 to 5.5		6 to 24		4.5 to 24		4.5 to 24		4.5 to 24		4.5 to 24	
Supply Current (mA max.)		4		10		10		10		10		10	
Output Type		Source		Source		Sink		Sink		Sink		Sink	
Output Voltage (V max.)		(Vs-1.5)		(Vs-1.5)		0.4		0.4		0.4		0.4	
Output Current (mA max.)		20		20		20		20		20		20	
Magnetics Type		Unipolar		Unipolar		Unipolar		Unipolar		Bipolar		Latching	
Magnetic Char. & Temp.		G	mT	G	mT	G	mT	G	mT	G	mT	G	mT
0 to 70°C	Max. Op.	735	73.5	495	49.5	475	47.5	—	—	180	18.0	90	9.0
	Min. Rel.	25	2.5	120	12.0	135	13.5	—	—	–180	–18.0	– 90	– 9.0
	Min. Dif.	50	5.0	40	4.0	40	4.0	—	—	40	4.0	40	4.0
–40 to 100°C	Max. Op.	—	—	—	—	495	49.5	160	16.0	205	20.5	120	12.0
	Min. Rel.	—	—	—	—	200	20.0	5	0.5	–205	–20.5	–120	–12.0
	Min. Dif.	—	—	—	—	35	3.5	8	0.8	35	3.5	40	4.0
25°C Typ.	Typ. Op.	350	35.0	350	35.0	400	40.0	90	9.0	50	5.0	50	5.0
	Typ. Rel.	215	21.5	245	24.5	250	25.0	45	4.5	– 50	– 5.0	– 50	– 5.0
	Typ. Dif.	135	13.5	85	8.5	85	8.5	45	4.5	100	10.0	80	8.0

* To order 1 meter jacketed leads, replace the 1 at the end of the catalog listing with a 2. Example 103SR13A-2.
** Stainless steel housing available for applications requiring compliance to NEMA 4X. Contact the 800 number.
G = Gauss
mT = milliTesla

Magnets page 25.

Unipolar: sensor has plus maximum operate point, plus minimum release point. One magnetic pole (South) is required to operate and release a unipolar sensor.

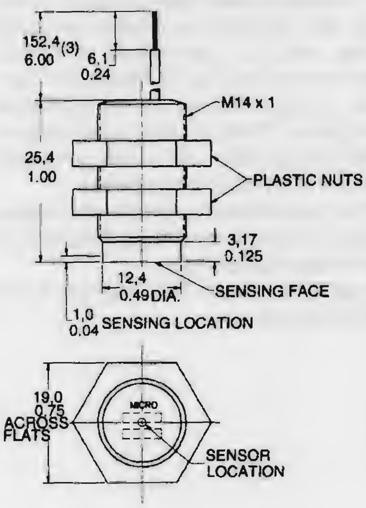
LEADWIRE TYPE

Type 1	22 gage stranded, teflon insulated
Type 2	22 gage PVC insulated conductor with black molded PVC jacket
Type 3	22 gage insulated conductors with yellow thermoplastic polyurethane jacket
Type 4	24 gage irradiated polyethylene

Bipolar sensor has plus (south pole) operate point and minus (north pole) minimum release point. Operate and release points can be both positive or both negative. **Latching cannot be guaranteed.** Ring magnets are usually used with bipolar sensors.

FEATURES
- Completely enclosed housing
- Color coded leadwires
- High speed, no-touch operation over 100 kHz possible
- Adjustable mounting
- Reverse polarity protection (bipolar listing)
- Meets NEMA 3, 3R, 3S, 4, 4X, 12 and 13 requirements
- Bushing is PBT (Valox 420 SEO) 30% glass filled

MOUNTING DIMENSIONS (For reference only)

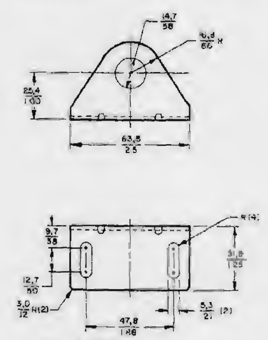


24AWG Leadwire color code:

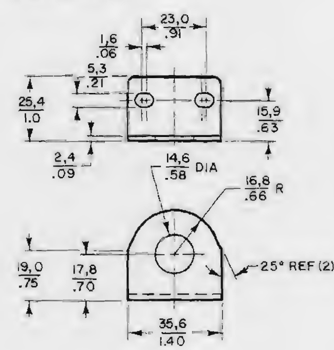
Red	Vs (+)
Green	Output
Black	Ground (–)

MOUNTING BRACKETS

1SR14M



1SR14MHD



SR3 ORDER GUIDE

Catalog Listings			SR3F-A1	SR3B-A1	SR3G-A1	SR3C-A1	SR4P2-A1
Supply Voltage (VDC)			4.5 to 24	4.5 to 24	4.5 to 24	4.5 to 24	6 to 24
Supply Current (mA max.)			18.0	15.0	22.0	19.0	13.5
Output Type			Sink	Sink	Sink	Sink	Sink
Output Voltage (V max.)			0.40	0.40	0.40	0.40	0.40
Current per Output (mA max.)			10	10	10	10	20
Magnetics Type			Unipolar (1)	Bipolar (2)	Unipolar (1)	Unipolar (1)	Omnipolar (3)
Magnetic Char. & Temp.			G mT	G mT	G mT	G mT	G mT
	–40 to 85°C	Max. Op.	450 45.0	150 15.0	430 43.0	190 19.0	25 2.5
	(–40 to +185°F)	Min. Rel.	170 17.0	–150 –15.0	160 16.0	60 6.0	5 0.5
		Min. Dif.	20 2.0	40 4.0	50 5.0	10 1.0	7 0.7
	25°C (+77°F)	Typ. Op.	400 40.0	90 9.0	350 35.0	150 15.0	15 1.5
	Typical	Typ. Rel.	185 18.5	– 90 – 9.0	280 28.0	100 10.0	11 1.1
		Typ. Dif.	20 2.0	80 8.0	70 7.0	30 3.0	4 0.4

(1) A unipolar sensor has a plus maximum operate point and a plus minimum release point. One magnetic pole (south) is required to operate and release a unipolar sensor.
(2) A bipolar sensor has a plus (south pole) maximum operate point and a minus (north pole) minimum release point. Operate and release points can be both positive, or both negative. **Latching cannot be guaranteed.** Ring magnets are usually used with bipolar sensors.
(3) An omnipolar sensor operates with any magnetic field (north or south pole).
(4) Operating characteristics are from –20°C to +85°C for SR4P2-A1.
(5) To order 1 meter jacketed leads, replace the 1 at end of listing with a 2.
Example: SR3B-A2.
G = Gauss
mT = milliTesla

Solid State Sensors

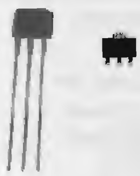
Analog Position Sensors

GENERAL INFORMATION

Analog devices are designed to produce an output voltage proportional to the intensity of the magnetic field to which it is exposed.

- Hall effect integrated circuit is mounted on a ceramic substrate. Laser trimmed thick film resistors on the ceramic substrate result in consistent sensitivity from one device to the next, and provide compensation for temperature variations. These analog position sensors feature three pin in-line terminals on .100 inch mounting centers.
- Small, cost-effective plastic packages. They are available on tape-and-reel for automated assembly.
- Rugged aluminum housing has color coded leadwires.

For absolute maximum ratings, see pages 75 and 76.



FEATURES

- 4 to 10 VDC supply voltage
- High output current capability – 10 mA continuous, 20 mA max.
- Ratiometric output
- Low supply current – 4 mA typ., for battery operation (@ 5V)
- Very small, industry accepted packages
- Available on tape and reel for automated assembly
- Responds to North or South pole
- Linear output voltage over wide magnetic flux range
- Best for applications with narrow temperature fluctuation

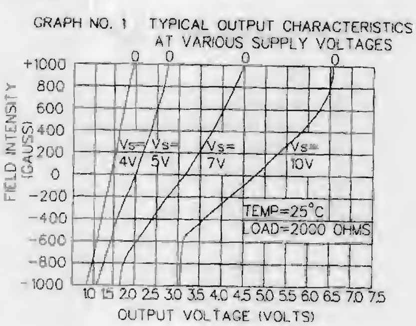
ORDER GUIDE

Catalog Listing	SS49/SS19/SS19T
Supply Voltage	4 to 10 VDC
Supply Current	4 mA typ.
Output Type	Sourcing
Output Voltage @ 0 Gauss	1.75 to 2.25 V @ 5 V, 25°C
Sensitivity (measured between –400 and +400 gauss)	0.60 to 1.25 mV/ gauss

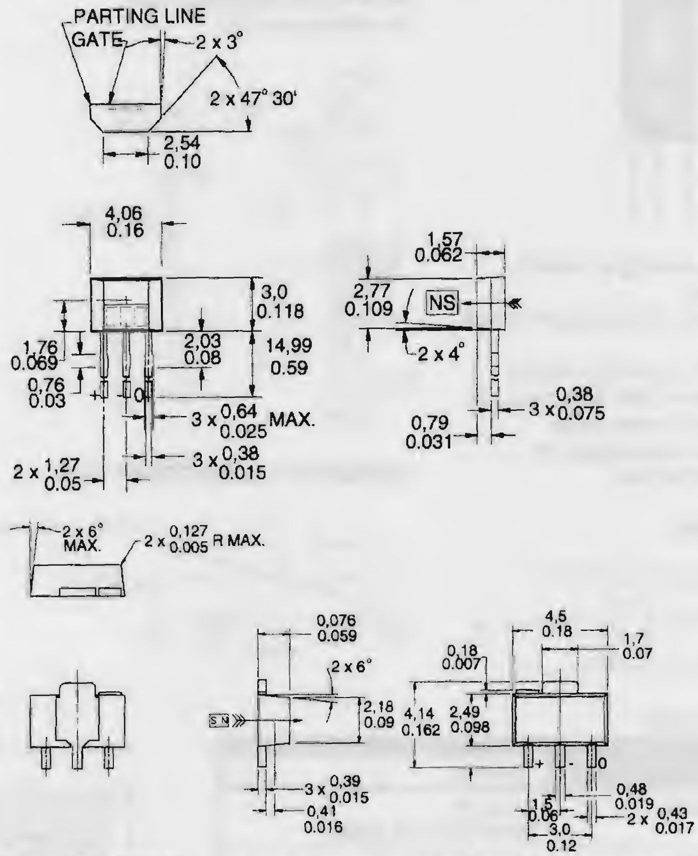
TYPICAL LINEAR OUTPUT CHARACTERISTICS*

Graph #1

This graph displays the relationship between supply voltage and the combined effects of a change in sensitivity (gain) and null voltage output at room temperature. The sensitivity variation is represented by a change in the slope of the curve. The null voltage shifts the entire curve.



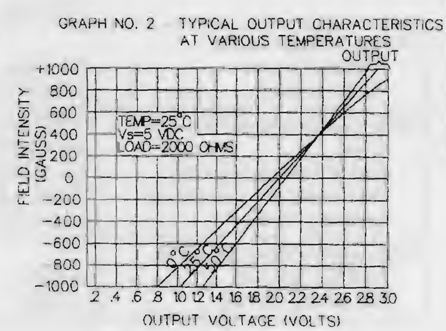
MOUNTING DIMENSIONS (For reference only)



Note: The SS19 is also available on tape and reel. Dimensions page 13.

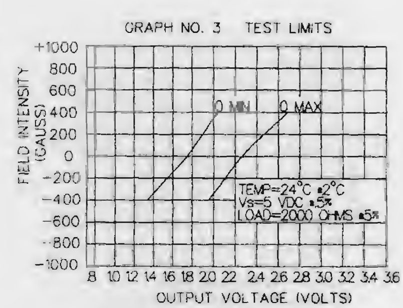
Graph #2

At 5 VDC supply voltage, these curves represent the typical performance of the SS49/SS19 over temperature.



Graph #3

This graph indicates the conditions under which we test the SS49/SS19, and defines the limits of the product. These limits do not take temperature or supply voltage variations into account.



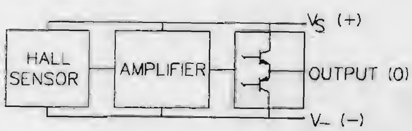
* Illustrated characteristics are typical. Production lot sensor characteristics will be in the general range of those shown.

Analog

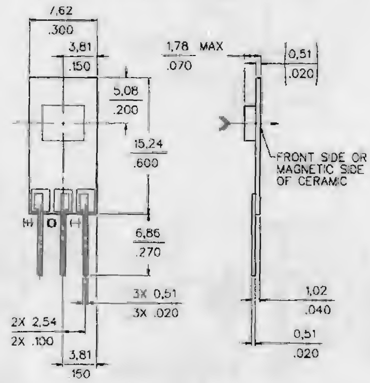
FEATURES

- Single current sinking or current sourcing output
- Three-pin in-line printed circuit board terminals
- Standard .100" mounting centers
- Laser trimmed thin film and thick film resistors minimize sensitivity variations and compensate for temperature variations

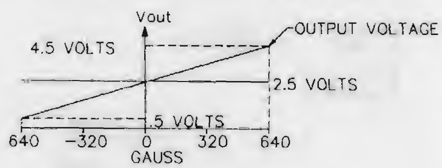
BLOCK DIAGRAM



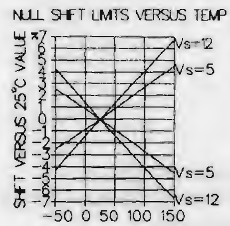
MOUNTING DIMENSIONS
(for reference only)

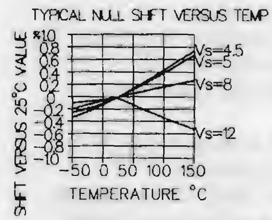


TRANSFER CHARACTERISTICS



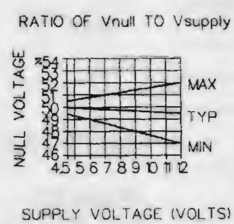
OUTPUT CHARACTERISTICS
(for reference only)

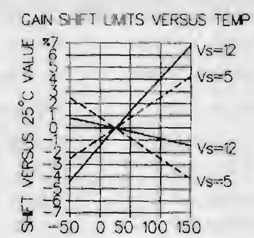


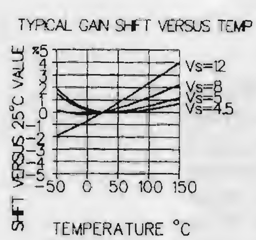


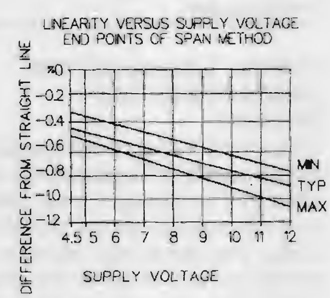
SS94 ORDER GUIDE

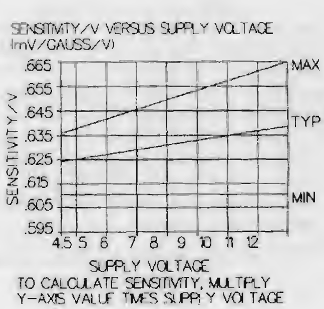
Catalog Listing	SS94B1
Supply Voltage (VDC)	4.5 to 12 Performance @ 5 VDC
Supply Current (mA)	8 typ., 11 max.
Output Current/Type	Ratiometric/Sinking or Sourcing 1 mA typ., 2 mA max.
Output Voltage Swing Negative gauss Positive gauss	 0.4 V typ. V_s - 0.4 V typ.
Magnetic Characteristics @ 25°C, 5 VDC (–67.0 to +67.0 mT,typ.)	
Span	4.0 V (–670 to +670 gauss, typ.),
Null (Offset @ 0 gauss)	2.5 ± 0.03 V
Sensitivity (mV per gauss)	3.125 ± 0.063
Linearity (% span)	-0.5 ± 0.5
Temperature Error (@ 25°C) Null Shift (%/°C) Sensitivity (%/°C)	 ± 0.03 ± 0.03

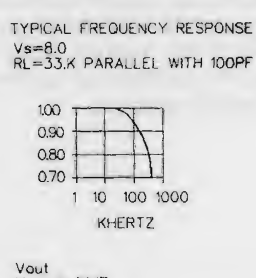


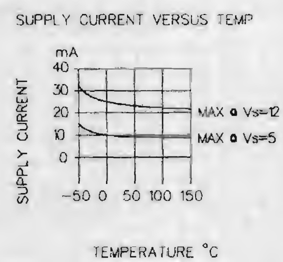




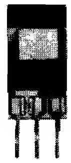








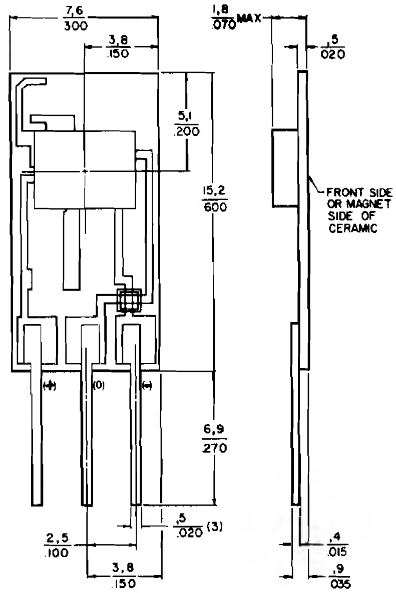
Solid State Sensors
Analog Position Sensors



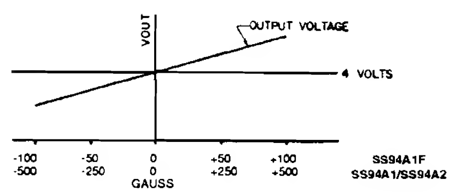
FEATURES
- Single current sinking or current sourcing linear output
- Improved temperature stability
- Three pin in-line printed circuit board terminals
- Standard .100″ mounting centers
- Laser trimmed thin film and thick film resistors minimize sensitivity variations and compensate for temperature variations
- Flux range of ±100 to ±2500 gauss

OPERATION
The SS9 utilizes a Hall effect integrated circuit chip which provides increased temperature stability and performance. Laser trimmed thick film resistors on the ceramic substrate and thin film resistors on the integrated circuit reduce null and gain shifts over temperature which results in consistent sensitivity from one device to the next.

MOUNTING DIMENSIONS (For reference only)
SS9



TYPICAL TRANSFER CHARACTERISTICS



SS9 ORDER GUIDE

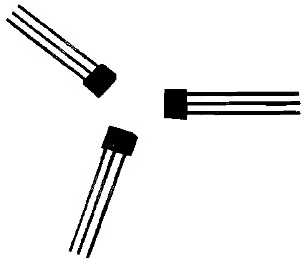
Catalog Listing	SS94A1	SS94A1B	SS94A1E	SS94A1F	SS94A2	SS94A2C	SS94A2D
Main Feature	Gen. purpose	5 VDC operation	Low drift	High sensitivity	Noise shielded††	Noise shielded††	Noise shielded††
Supply Voltage (VDC)*	6.6 to 12.6	4.5 to 8.0	6.6 to 12.6	6.6 to 12.6	6.6 to 12.6	6.6 to 12.6	6.6 to 12.6
Supply Current (mA)**	13 typ. 30 max.	8 typ. 17.5 max.	13 typ. 30 max.	13 typ. 30 max.	13 typ. 30 max.	13 typ. 30 max.	13 typ. 30 max.
Output Current (mA) Sinking or Sourcing	1 max.	1 max.	1 max.	1 max.	1 max.	1 max.	1 max.
Response Time (μ sec.)	3 typ.	3 typ.	3 typ.	3 typ.	3 typ.	3 typ.	3 typ.
Magnetic Characteristics*** Span*	.625 V_S	.375 V_S	.625 V_S	.625 V_S	.625 V_S	.625 V_S	.625 V_S
Range (gauss)*	-500 to +500	-500 to +500	-500 to +500	-100 to +100	-500 to +500	-1000 to +1000	-2500 to +2500
Sensitivity (mV/gauss @ 25°C)	5.0±.1	1.875±.100	5.0±.1	25.0±.5	5.0±.1	2.50±.05	1.00±.02
Linearity† (% span)	-0.8 typ. -1.5 max.	-0.8 typ. -1.5 max.	-0.8 typ. -1.5 max.	-0.8 typ. -1.5 max.	-0.8 typ. -1.5 max.	-0.8 typ. -1.5 max.	-0.8 typ. -1.5 max.
Vout (0 gauss @ 25°C)***	4.00±.04V	2.50±.05V	4.00±.04V	4.00±.08V	4.00±.04V	4.00±.04V	4.00±.04V
Temperature Error (all %s reference 25°C value)* Null (%/°C)	±.02	±.025	±.01	±.10	±.02	±.0125	±.007
Gain (%/°C)	±.02	±.025	±.02	+.02 -.055	±.02	±.02	±.02

* -40° to 125°C.
MilliTesla = Gauss 10^{-1}
** Excludes load. Typical at 25°C/Maximum at -40°C.
*** @ V_s = 5 VDC for SS94A1B only/@ V_s = 8 VDC for all others.
† Derived from straight line between end points.
†† Silver coating on back of ceramic is electrically connected to – terminal.
Specified using a 2.2KΩ resistor unless otherwise noted.

Null voltage (Vout at 0 gauss) and sensitivity are ratiometric to supply voltage.

Magnets page 25.

Application consideration: The output is clamped at the high end. Clamping voltage may be as low as 9VDC. The output will not exceed the clamping voltage regardless of field strength or supply voltage.



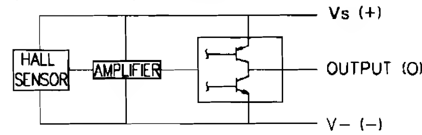
FEATURES
- Small size (.160 × .118″)
- Low power consumption - typically 7 mA at 5 VDC
- Single current sinking or current sourcing linear output
- Built-in thin-film resistors - laser trimmed for precise sensitivity and temperature compensation
- Rail-to-rail operation provides more useable signal for higher accuracy
- Operating temperature range of –40 to +150°C
- Responds to either positive or negative gauss
- Quad Hall sensing element for stable output

SS490 Series MRL (Miniature Ratiometric Linear) sensors have a ratiometric output voltage, set by the supply voltage. It varies in proportion to the strength of the magnetic field.

A new Hall effect integrated circuit chip provides increased temperature stability and sensitivity. Laser trimmed thin film resistors on the chip provide high accuracy (null to ±3%, sensitivity up to ±3%) and temperature compensation to reduce null and gain shift over temperature. The quad Hall sensing element minimizes the effects of mechanical or thermal stress on the output. The positive temperature coefficient of the sensitivity (+0.02%/°C typical) helps compensate for the negative temperature coefficients of low cost magnets, providing a robust design over a wide temperature range.

NOTICE
Products ordered in bulk packaging (plastic bags) may not have perfectly straight leads as a result of normal handling and shipping operations. Please order tape packaging option for applications with critical lead straightness requirements.

CIRCUIT BLOCK DIAGRAM

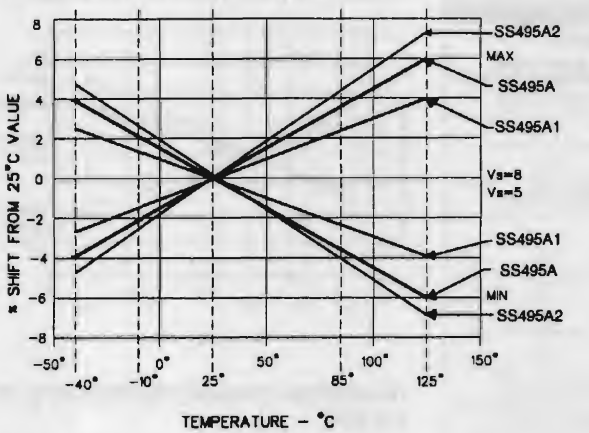


SS495 SPECIFICATIONS, V_S = 5.0 V, T_A = –40 to +125°C (unless otherwise noted)

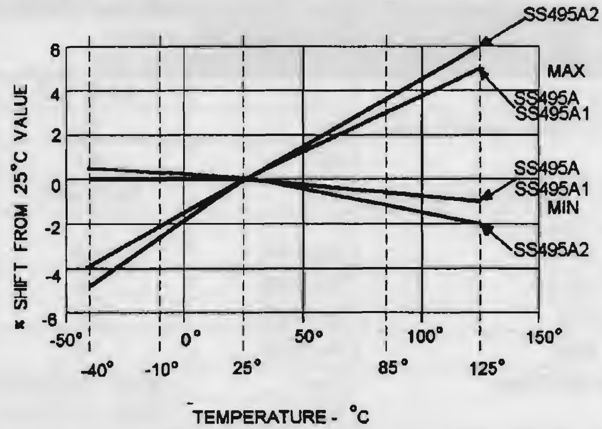
Catalog Listings		SS495A* Standard	SS495A1* High Accuracy	SS495A2* Basic
Supply Voltage (VDC)		4.5 to 10.5	4.5 to 10.5	4.5 to 10.5
Supply Current @ 25°C (mA)	Typ.	7.0	7.0	7.0
	Max.	8.7	8.7	8.7
Output Type (Sink or Source)		Ratiometric	Ratiometric	Ratiometric
Output Current (mA) Typ. Source	Vs>4.5V	1.5	1.5	1.5
Min. Source	Vs>4.5V	1.0	1.0	1.0
Min. Sink	Vs>4.5V	0.6	0.6	0.6
Min. Sink	Vs>5.0V	1.0	1.0	1.0
Magnetic Range	Typ.	–670 to +670 Gauss (–67 to +67 mT)		
	Min.	–600 to +600 Gauss (–60 to +60 mT)		
Output Voltage Span	Typ.	0.2 to (Vs - 0.2)	0.2 to (Vs - 0.2)	0.2 to (Vs - 0.2)
	Min.	0.4 to (Vs - 0.4)	0.4 to (Vs - 0.4)	0.4 to (Vs - 0.4)
Null (Output @ 0 Gauss, V)		2.50 ± 0.075	2.50 ± 0.075	2.50 ± 0.100
Sensitivity (mV/G)		3.125 ± 0.125	3.125 ± 0.094	3.125 ± 0.156
Linearity, % of Span	Typ.	–1.0%	–1.0%	–1.0%
	Max.	–1.5%	–1.5%	–1.5%
Temperature Error Null Drift (%/°C)		±0.06%	±0.04%	±0.07%
Sensitivity Drift (%/°C)	≥25°C Max.	–0.01%+0.05%	–0.01%+0.05%	–0.02%+0.06%
	<25°C Max.	–0.00%+0.06%	–0.00%+0.06%	–0.01%+0.07%

*Bulk, 1,000 per bag
To order Surface Mount: add -S suffix to listing. Example: SS495A-S.
To order tape in Ammopack style T2: add -T2 suffix to listing.
To order tape in Ammopack style T3: add -T3 suffix to listing.
To order tape in reel style P (surface mount): add -SP suffix to listing.

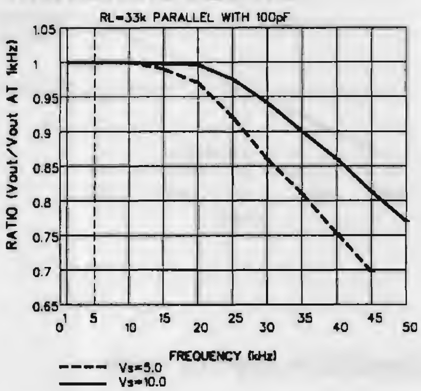
NULL SHIFT VS TEMPERATURE



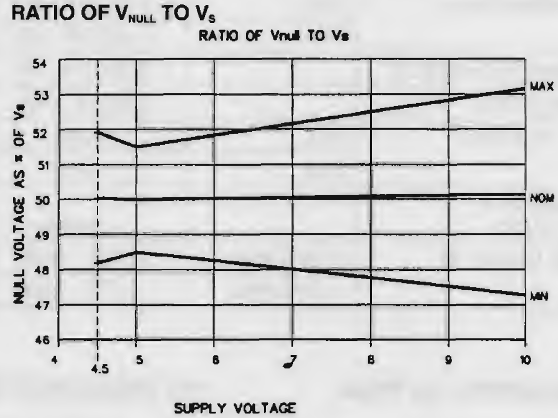
SENSITIVITY SHIFT VS TEMPERATURE



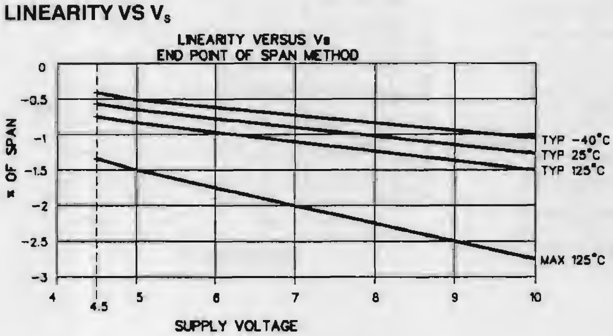
TYP. FREQUENCY RESPONSE



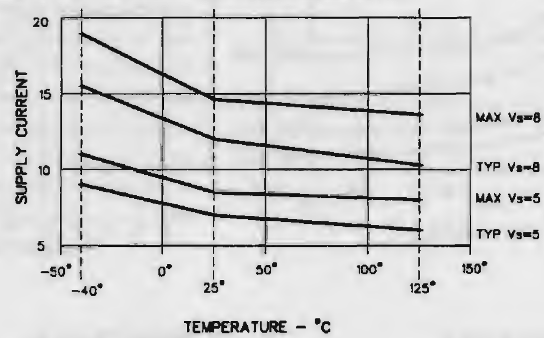
RATIO OF V_{NULL} TO V_S



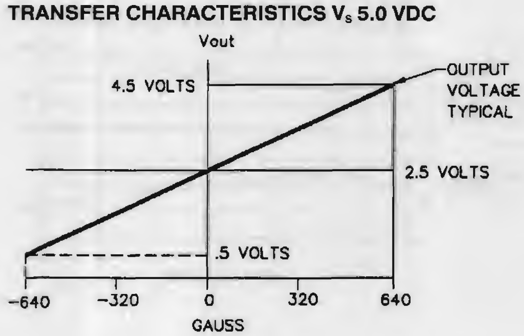
LINEARITY VS V_S



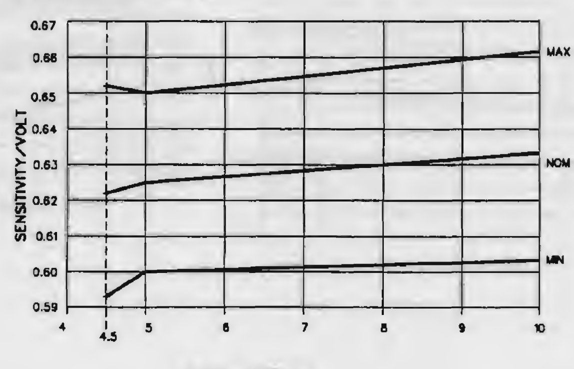
SUPPLY CURRENT VS TEMPERATURE



TRANSFER CHARACTERISTICS V_S 5.0 VDC



SENSITIVITY/V VS V_S

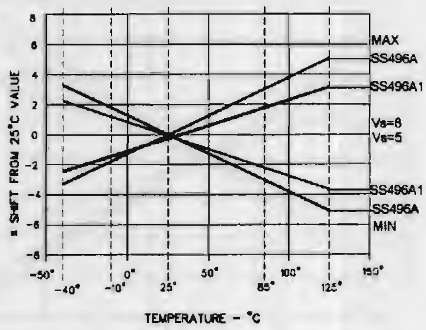


Analog

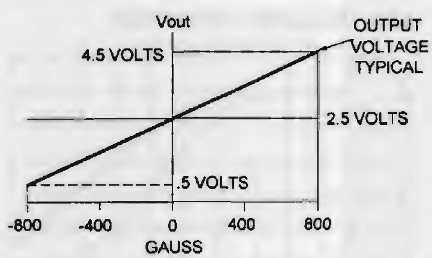
SS496 SPECIFICATIONS, V_S = 5.0 V, T_A = –40 to +125°C (unless otherwise noted)

Catalog Listings		SS496A Standard	SS496A1 High Accuracy
Supply Voltage, DC		4.5 to 10.5	4.5 to 10.5
Supply Current @ 25°C (mA)	Typ.	7.0	7.0
	Max.	8.7	8.7
Output Type (Sink or Source)		Ratiometric	Ratiometric
Output Current, mA			
Typ. Source	Vs>4.5V	1.5	1.5
Min. Source	Vs>4.5V	1.0	1.0
Min. Sink	Vs>4.5V	0.6	0.6
Min. Sink	Vs>5.0V	1.0	1.0
Magnetic Range	Typ.	–840 to +840 Gauss (–84 to +84 mT)	
	Min.	–750 to +750 Gauss (–75 to +75 mT)	
Output Voltage Span	Typ.	0.2 to (Vs - 0.2)	0.2 to (Vs - 0.2)
	Min.	0.4 to (Vs - 0.4)	0.4 to (Vs - 0.4)
Null (Output @ 0 Gauss, V)		2.500 ± 0.175	2.500 ± 0.075
Sensitivity (mV/G)		2.500 ± 0.100	2.50 ± 0.075
Linearity, % of Span	Typ.	–1.0%	–1.0%
	Max.	–1.5%	–1.5%
Temperature Error Null Drift (%/°C)		±0.048%	±0.032%
Sensitivity Drift (%/°C)	≥25°C Max.	–0.01, +0.05	–0.01, +0.06
	<25°C Max.	–0.00, +0.06	–0.00, +0.06

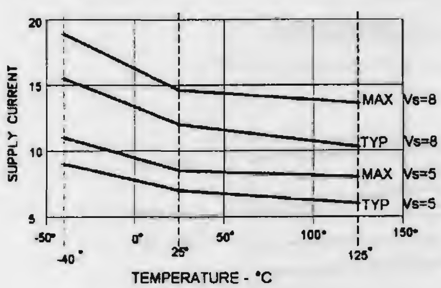
NULL SHIFT VS TEMPERATURE



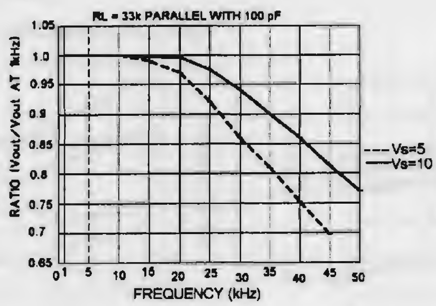
TRANSFER CHARACTERISTICS @ VS = 5 VDC



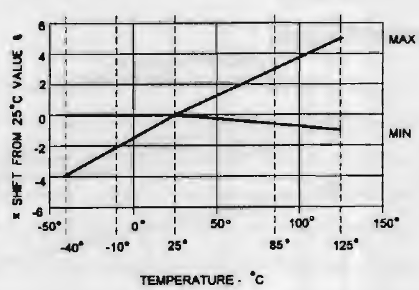
SUPPLY CURRENT VS TEMP.



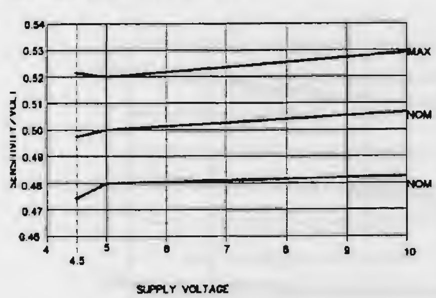
TYP. FREQUENCY RESPONSE



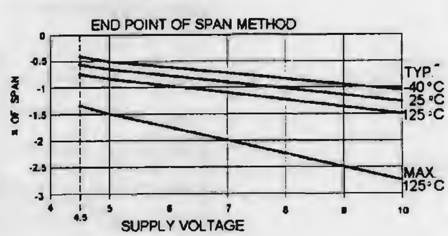
SENSITIVITY SHIFT VS TEMP



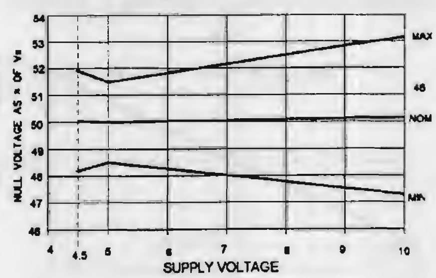
SENSITIVITY/V VS V_S



LINEARITY VS V_S

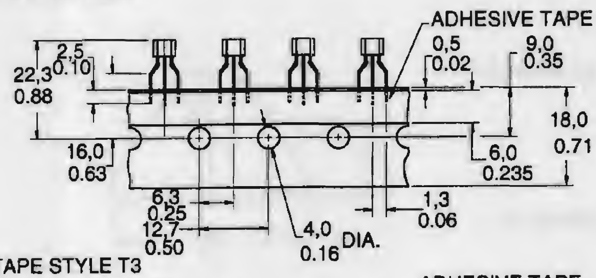


RATIO OF V_{NULL} TO V_S

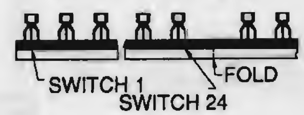


MOUNTING DIMENSIONS (for reference only)

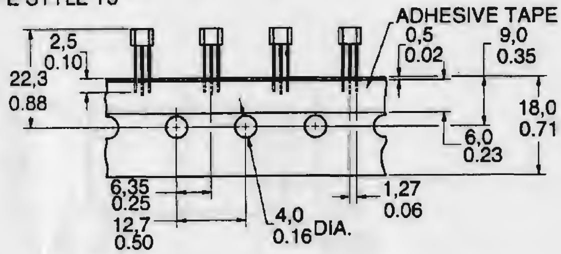
TAPE STYLE T2



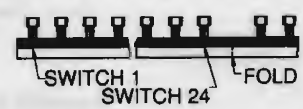
AMMOPACK STYLE T2



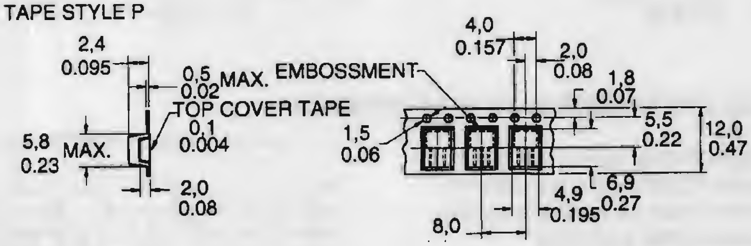
TAPE STYLE T3

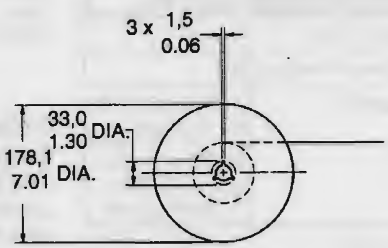


AMMOPACK STYLE T3

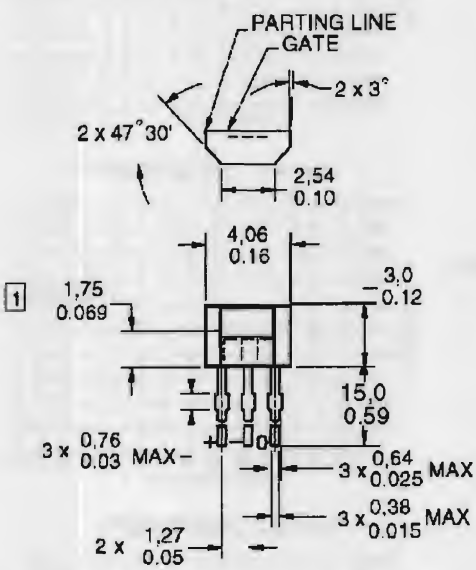


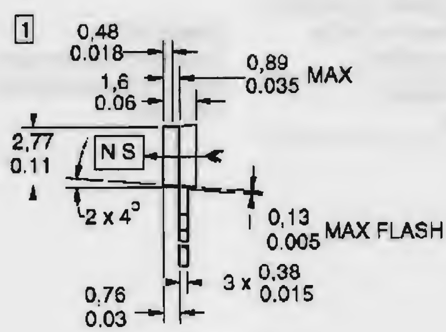
TAPE STYLE P



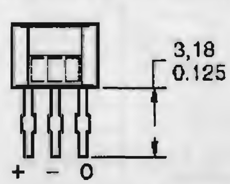


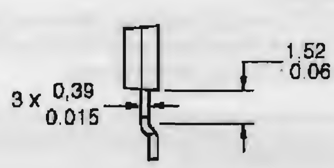
SENSOR PACKAGE





OPTIONAL SURFACE MOUNT STYLE





1 Centerline of Hall cell

Analog

FEATURES

- Rugged, sealed threaded aluminum housing NEMA 3, 3R, 3S, 4, 12 and 13 requirements
- 22 gauge, 6 inch stranded leadwires, color coded and teflon insulated
- Adjustable mounting

NOTE: For digital sensors, see page 14.

103SR ORDER GUIDE

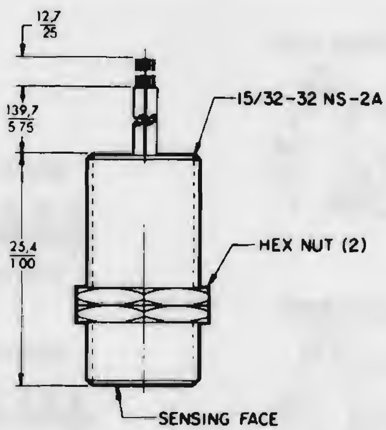
Catalog Listing	103SR3F-5
Supply Voltage (VDC)	4 to 10
Supply Current (mA max.)	3.5
Output Voltage (V)	1.75 to 2.25V at 5V, 0 gauss
Sensitivity	(–400 to +400 gauss) 0.75 to 1.06mV/gauss

mT = Gauss × 10⁻¹

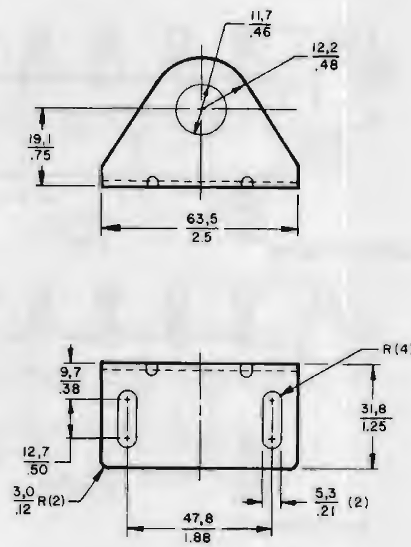
LEADWIRE TYPE

Type 1	22 gage stranded, teflon insulated
Type 2	22 gage PVC insulated conductor with black molded PVC jacket
Type 3	22 gage insulated conductors with yellow thermoplastic polyurethane jacket
Type 4	24 gage irradiated polyethylene

MOUNTING DIMENSIONS (For reference only)



1SR15 Mounting Bracket

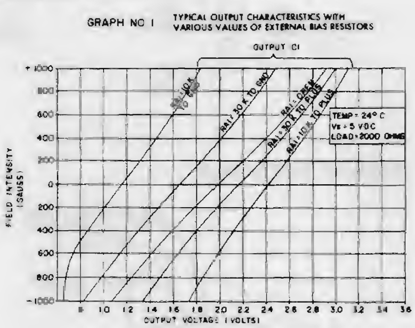


Leadwire color code:

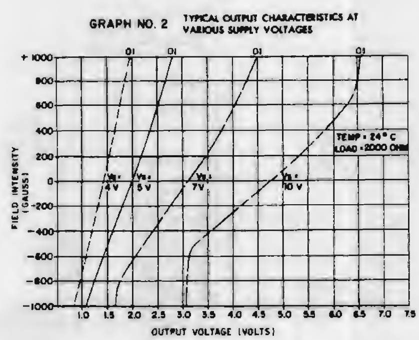
Red	Vs (+)
Black	Ground (–)
Gray	Linear Output
White	R Adjust

TYPICAL LINEAR OUTPUT CHARACTERISTICS*

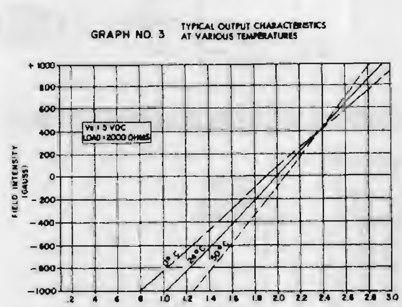
Graph #1
The 103SR3F-5 features a single adjustable linear output. An external bias resistor can be used to vary the zero gauss offset (null) and consequently, the output voltage.



Graph #2
These curves represent the typical output characteristics at various supply voltages.

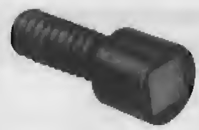


Graph #3
At 5 VDC supply voltage, these curves represent the typical performance of the 103SR3F-5 over temperature.



* Illustrated characteristics are typical. Production lot sensor characteristics will be in the general range of those shown.

Solid State Sensors
Magnets



GENERAL INFORMATION

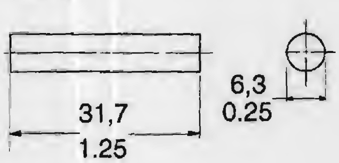
Several bar and ring magnets for actuating Hall effect sensors are available from MICRO SWITCH. Bar magnets, in various sizes and strengths, are ideal for sensors with unipolar magnetic characteristics. The ring magnets, with alternate South and North poles on the outside diameter, are especially useful for sensors with bipolar magnetic characteristics. (For more information on magnets and methods of magnet actuation, see Application Data.)

FEATURES

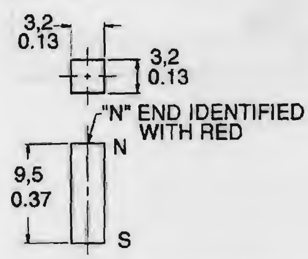
- Wide variety of sizes and shapes
- Wide variety of magnetic materials
- Threaded bushings available on some listings for easy installation

MOUNTING DIMENSIONS (for reference only)

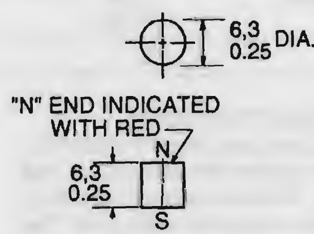
101MG3



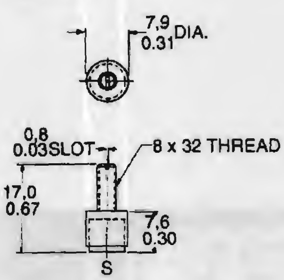
101MG2L1



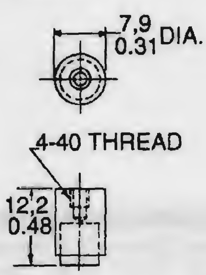
101MG7



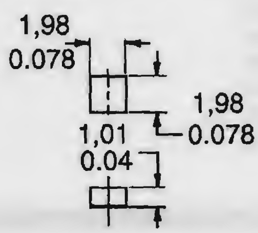
102MG11



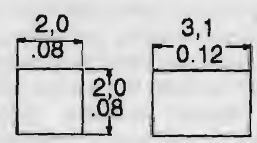
102MG15



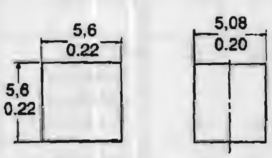
103MG5



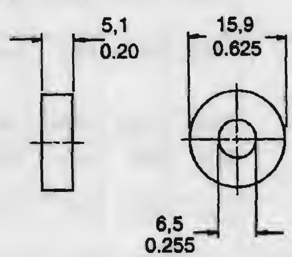
103MG6



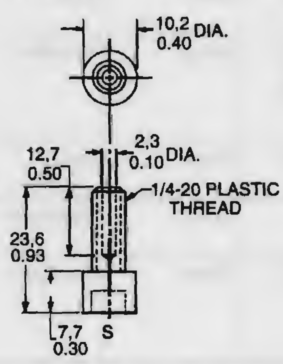
103MG8



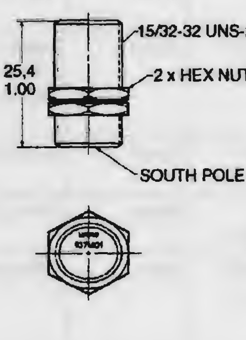
105MG5R2



106MG10



107MG1



Analog

MG ORDER GUIDE — BAR MAGNETS

Catalog Listings	101MG3	101MG7*	101MG2L1*	102MG11*	102MG15*	103MG5**	103MG6***	103MG8	106MG10*	107MG1
Outside Diameter	6,3 0.25	6,3 0.25	3,2 0.125	7,9 0.31	7,9 0.31	2,0 .078	2,0 .080	5,6 .220	10,2 0.40	15/32-32 UNS21
Length	31,7 1.25	6,3 0.25	9,5 0.375	17,0 0.67	12,2 .48	2,0 .078	3,1 .120	5,6 .220	23,6 0.93	25,4 1.00

* Bulk packaging in 100 unit lots. Add **-BP** to catalog listing.
** 125 pieces per tube. Poles not marked.
*** 75 pieces per tube. Poles not marked.

MG ORDER GUIDE — RING MAGNETS

Catalog Listings	105MG5R2	105MG5R4
Outside Diameter	15,9 0.625	15,9 0.625
# Pole Pairs	2	4

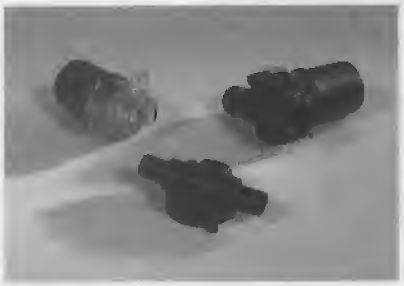
MAGNET SELECTION GUIDE

This guide is designed to aid in determining the best magnet for use with a Hall effect sensor. There are several factors to consider when choosing a magnet. The most important is gap distances. There must be adequate magnetic gauss to operate the sensor at the correct distance. By using the maximum operate magnetic gauss characteristics (see sensor order guides), you can determine which magnet(s) will operate the sensor. Other important factors include temperature range and the physical environment of the application.

Material and Process	Physical Strength	Temperature Range*	Magnetic Shock Resistance	Resistance To Demagnetization	Gap Distance** & Gauss Level @ 25°C† 0,25 .010	0,76 .030	1,27 .050	2,54 .100	3,81 .150	5,08 .200	Catalog Listing
Alnico V Cast	Good	−40 to 300°C	Poor	Fair	1460	1320	1170	810	575	420	101MG3
Alnico VIII Sintered	Good	−40 to 250°C −40 to 140°C −40 to 140°C	Good	Excellent	1050 7800	900 7800	755 7800	470 750	295 550	195 375	101MG7 102MG11 102MG15 107MG1***
Alnico VI Sintered	Good	−40 to 250°C	Good	Good	730	550	410	205	115	75	101MG2L1
Indox 1 Pressed	Good	0 to 100°C	Good	Excellent	700	520	375	175	85	45	105MG5R2 105MG5R4
Rare Earth Pressed	Poor	−40 to 250°C	Good	Excellent	1110 2900 2620 2620	630 1400 2100 2100	365 850 1600 1600	120 260 940 940	55 130 550 550	25 70 350 350	103MG5 103MG6 103MG8 106MG10

* Magnet will not be damaged over temperature range.
** Gap distance from sensing surface.
*** Measurement device saturated @ 800 gauss.
†milliTesla = Gauss × 10^{-1}

Turbidity Sensors
Wash Process Sensors



FEATURES
- Low-cost infrared turbidity sensing
- Multiple sensors in a single package for simple integration
- Ratio turbidity output to minimize common-mode effects
- Flow-through covers available for hose applications and simple retrofit
- On-board microprocessor for signal conditioning and communications

TYPICAL APPLICATIONS
- Parts washers
- Printed circuit board washers
- Plating rinse baths
- Industrial and coin-operated laundry machines
- Commercial dishwashers
- Mixing tanks
- Water treatment equipment

OPERATION
The APMS-10G Wash Process Sensor provides an integrated package consisting of a microprocessor and three sensing functions:
- Turbidity
- Conductivity
- Temperature

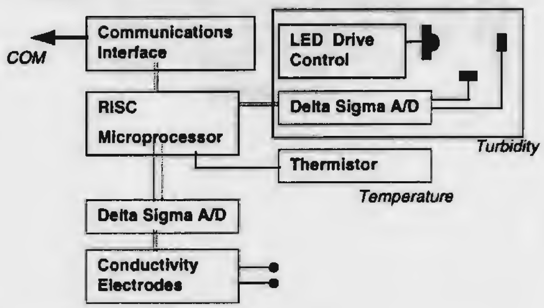
The sensor can monitor and control an application process to improve the quality of the process, minimizing the consumption of energy, water, materials and time.

Each sensor output is conditioned by the internal microprocessor. All data transmitted to the host system is supplied by the microprocessor via a 5 VDC serial communications link. The sensor operates in slave mode, waiting for the host system to request sensor information.

ORDER GUIDE

Catalog Listings	Sensor Included	Flow-through Cap Installed
APMS-10GRCF	Yes	No
APMS-10GRCF-50	Yes	.5 inch OD
APMS-10GRCF-18	Yes	18 mm OD
APMS-10GRCF-KIT	Yes	Both, not installed Kit includes sensor, flow-through caps, PC interface, and software

WASH PROCESS SENSOR FUNCTIONAL DIAGRAM



GENERAL SPECIFICATIONS

Parameter	Min.	Typ.	Max.	Units
Supply Voltage	8	24	30	Volts DC
Supply Current		16	40	mA
Output Voltage				
Sensor Transmit Low	0		1.1	volts*
Sensor Transmit High	4	5	5.25	volts*
Sensor Receive Low	0		1.7	volts*
Sensor Receive High	3.3		5.25	volts*

* Assumes a sinking output current of 3 mA maximum.

TURBIDITY SPECIFICATIONS

Characteristic	Min.	Typ.	Max.	Units
Ratio Range	0		4000	NTU
	.03		10	units
Response Time			1.3	seconds

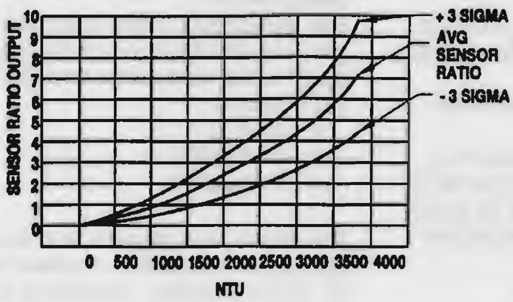
CONDUCTIVITY SPECIFICATIONS

Characteristic	Min.	Typ.	Max.	Units
Range	.0001		15	mSiemens
Range	4		255	units
Response Time			0.85	second

TEMPERATURE SPECIFICATIONS

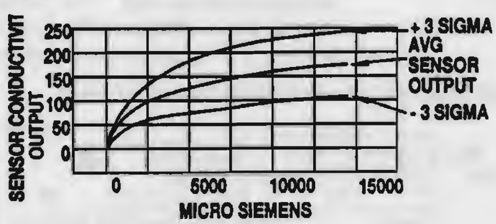
Characteristic	Min.	Typ.	Max.	Units
Range	68		140	°F
Accuracy	-4		+4	°F
Response Time			0.03	second
Stabilization Time	3		5	minutes

TURBIDITY CHARACTERISTICS

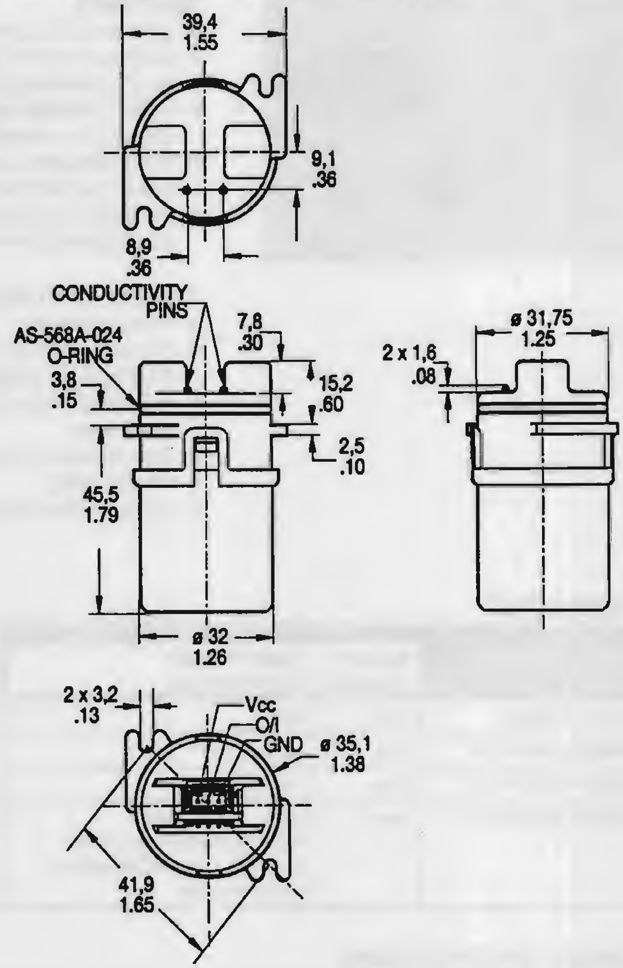


This graph is based on testing using formazin as the medium at room temperature. Characteristics may change when sensor is subjected to media other than formazin.

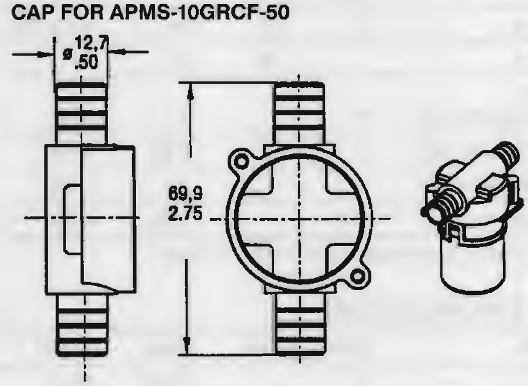
CONDUCTIVITY ACCURACY



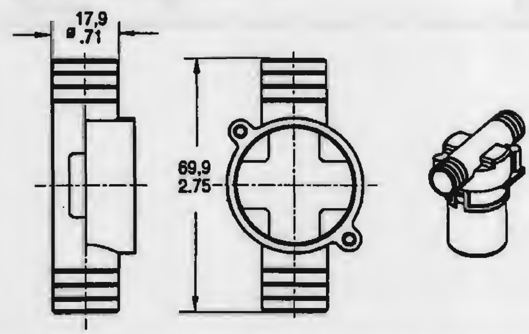
MOUNTING DIMENSIONS (for reference only)



CAP FOR APMS-10GRCF-50



CAP FOR APMS-10GRCF-18



FEATURES

- Interchangeable without sensor-to-sensor recalibration
- Very small thermal mass for fast response
- Air or liquid temperature sensing
- Linear temperature sensitivity
- Proven thin film processing reliability
- Low cost
- Long term stability
- 2000 ohms nominal resistance at 20°C

TYPICAL APPLICATIONS

- HVAC – room, duct and refrigerant temperature
- Motors – overload protection
- Electronic circuits – semiconductor protection
- Process control – temperature regulation
- Automotive – air or oil temperature
- Appliances – cooking temperature

GENERAL INFORMATION

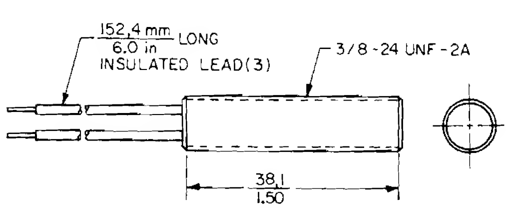
TD Series temperature sensors from MICRO SWITCH respond rapidly to temperature changes, and are accurate to ±0.7°C at 20°C—completely interchangeable without recalibration. They are RTD (resistance temperature detector) sensors, and provide 8 Ω/°C sensitivity, with inherently near linear outputs.

The sensing element is a silicon chip, 0.040 × 0.050" with a thin film resistive network pattern. The chips are individually laser trimmed to provide 2000 ohms nominal resistance at room temperature (20°C), accurate to ±0.7°C. Maximum error over the entire operating range of –40 to +150°C (–40 to +302°F) is ±2.5°C. This extremely accurate trimming provides true sensor-to-sensor interchangeability without recalibration of the user circuit.

TD4A Liquid temperature sensor
TD4A liquid temperature sensor is a two-terminal threaded anodized aluminum housing. The environmentally sealed liquid temperature sensors are designed for simplicity of installation, such as in the side of a truck. TD4A sensors are not designed for total immersion. Typical response time (for one time constant) is 4 minutes in still air and 15 seconds in still water (unmounted position). The temperature rise is 0.12°C/milliwatt suspended by leads in still air, and 0.08°C/milliwatt when mounted on 1 square foot 0.25" thick aluminum foil.

TD5A Miniature temperature sensor
The TD5A is a subminiature temperature sensor with three leads (center not connected). It has response times of 11.0 seconds and a temperature rise of .23°C per milliwatt in still air.

TD4A

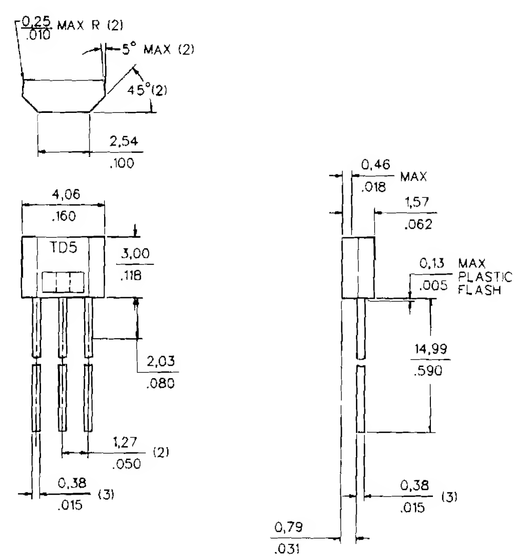


TD ORDER GUIDE

Catalog Listing	Description
TD4A	Liquid temperature sensor, 1.5° threaded (⅜-24 UNF-2A) anodized aluminum housing, two six inch black insulated leads
TD5A	Subminiature package, low cost, fast response time (TO-92)

MOUNTING DIMENSIONS (for reference only)

TD5A



Center lead not connected

Temperature

ABSOLUTE MAXIMUM RATINGS

Operating temperature range	–40 to +150°C (–40 to +302°F)
Storage temperature range	–55 to 165°C (–67 to +338°F)
Voltage	10 VDC Continuous (24 hours)

INTERCHANGEABILITY (with 100 μA maximum current)

Temperature	Resistance (Ohms)	Temperature	Resistance (Ohms)
-40°C (–40°F)	1584 ± 12 (1.9°C)	+60°C (140°F)	2314 ± 9 (1.1°C)
-30°C (–22°F)	1649 ± 11 (1.7°C)	+70°C (158°F)	2397 ± 10 (1.2°C)
-20°C (–4°F)	1715 ± 10 (1.5°C)	+80°C (176°F)	2482 ± 12 (1.4°C)
–10°C (14°F)	1784 ± 9 (1.3°C)	+90°C (194°F)	2569 ± 14 (1.6°C)
0°C (32°F)	1854 ± 8 (1.1°C)	+100°C (212°F)	2658 ± 16 (1.8°C)
+10°C (50°F)	1926 ± 6 (0.8°C)	+110°C (230°F)	2748 ± 18 (2.0°C)
+20°C (68°F)	2000 ± 5 (0.7°C)	+120°C (248°F)	2840 ± 19 (2.0°C)
+30°C (86°F)	2076 ± 5 (0.7°C)	+130°C (266°F)	2934 ± 21 (2.2°C)
+40°C (104°F)	2153 ± 6 (0.8°C)	+140°C (284°F)	3030 ± 23 (2.4°C)
+50°C (122°F)	2233 ± 7 (0.9°C)	+150°C (302°F)	3128 ± 25 (2.5°C)

It is recommended that resistance measurements be made at 100 μA or less to minimize internal heating of the sensor. Measurements at currents up to 1mA will not damage the sensor, but the resistance characteristics should be adjusted for internal heating.

Equation for computing resistance:

$R_T = R_O + (3.84 \times 10^{-3} \times R_O \times T) + (4.94 \times 10^{-6} \times R_O \times T^2)$

R_T = Resistance at temperature T

R_O = Resistance at 0°C

T = Temperature in °C

Figure 2
Linear Output Voltage Circuit

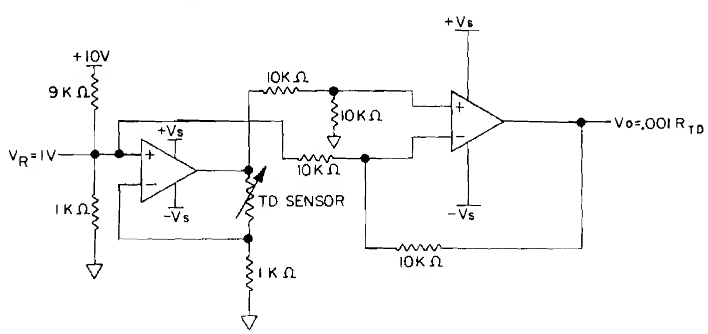
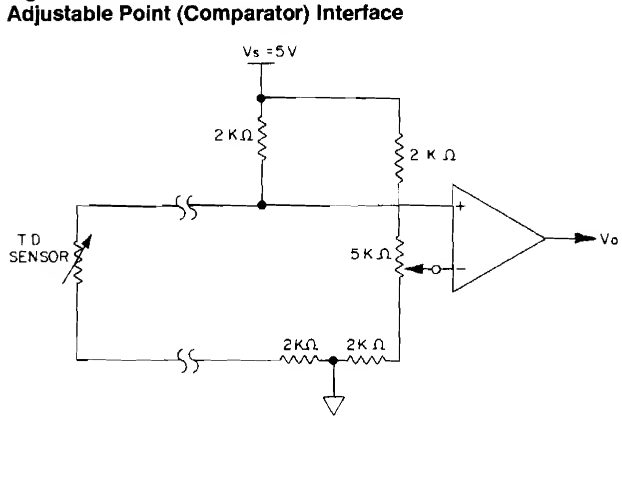


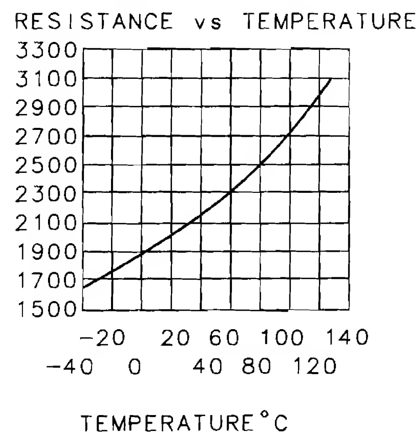
Figure 3
Adjustable Point (Comparator) Interface



Linearity
±2% (-25 to 85°C)
±3% (–40 to 150°C)
TD sensors can be linearized to within ±0.2%.

Repeatability
± 1 Ω

Figure 1
TD Series Resistance vs Temperature



ELECTRICAL INTERFACING

The high nominal resistance, positive temperature coefficient and linear sensitivity characteristics of the TD Series temperature sensors simplifies the task of designing the electrical interface. Figure 2 is a simple circuit that can be used to linearize the voltage output to within 0.2% or a ± 0.4°C error over a range of –40 to +150°C (–40 to +302°F).

In some applications, it may be desirable to detect one particular temperature. Figure 3 illustrates one way this can be accomplished. In the comparator circuit shown, the potentiometer can be adjusted to correspond to the desired temperature.

FEATURES

- Linear resistance vs temperature
- Accurate and Interchangeable
- Excellent stability
- Small for fast response
- Wide temperature range
- 3-packaging options

TYPICAL APPLICATIONS

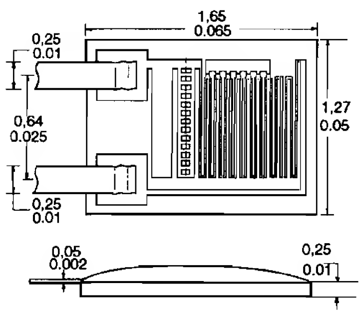
- HVAC - room, duct and refrigerant equipment
- Electronic assemblies - thermal management, temperature compensation
- Process control - temperature regulation

HEL-700 Thin Film Platinum RTDs (Resistance Temperature Detectors) provide excellent linearity, accuracy, stability and interchangeability. Resistance changes linearly with temperature. Laser trimming provides ±0.3°C interchangeability at 25°C.

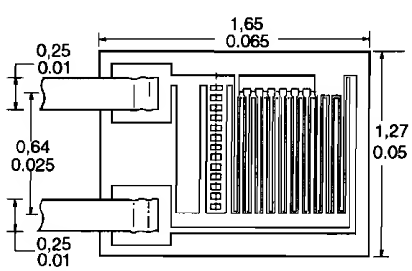
1000Ω, 375 alpha provides 10X greater sensitivity and signal-to-noise. Both 1000Ω and 100Ω provide interchangeabilities of ±0.6°C or better from -100°C to 100C, and ±3.0°C at 500°C.

MOUNTING DIMENSIONS (for reference only)

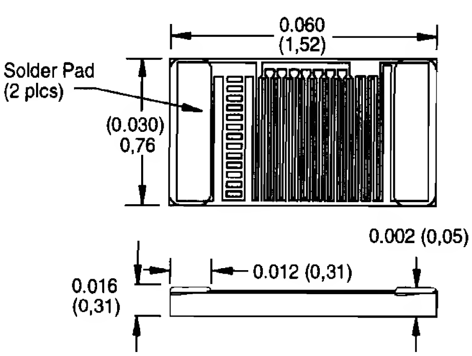
HEL-700 Ribbon Lead



HEL-700 Axial Chip



HEL-700 SMT Flip Chip



ORDER GUIDE

HEL-700	Thin Film Platinum RTD				
	-U	1000Ω, 0.00375 Ω/Ω/°C			
	-T	100Ω, 0.00385 Ω/Ω/°C DIN Standard			
		-0	±0.2% Resistance Trim (Standard)		
		-1	±0.1% Resistance Trim (Optional)		
				-A	Radial Ribbon Lead
				-B	Radial Chip
				-C	SMT Axial Flip Chip (1000Ω **ONLY)**

Fig. 1: Linear Output Voltage

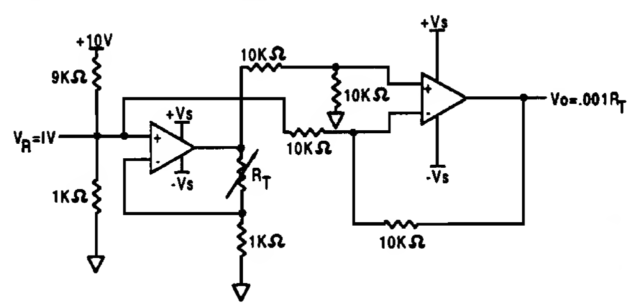
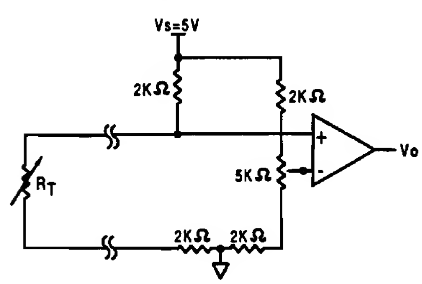


Fig. 2: Adjustable Point (Comparator) Interface



THE PRODUCTS ON PAGES 31 THROUGH 46 ARE NOT ISO CERTIFIED.

ISO CERTIFICATION IS PLANNED FOR EARLY 1999.

FUNCTIONAL BEHAVIOR

$R_T = R_0(1+AT+BT^2-100CT^3+CT^4)$
RT = Resistance (Ω) at temperature T (°C)
R_0 = Resistance (Ω) at 0°C
T = Temperature in °C

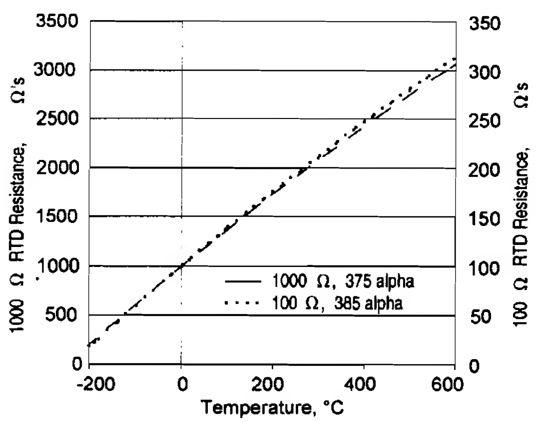
$A = \alpha + \frac{\alpha\,\delta}{100}$ $B = \frac{-\alpha\,\delta}{100^2}$ $C_{T<0} = \frac{-\alpha\,\beta}{100^4}$

CONSTANTS

Alpha, α (°C^{-1})	0.00375 ±0.000029	0.003850 ±0.000010
Delta, δ (°C)	1.605 ± 0.009	1.4999 ± 0.007
Beta, β (°C)	0.16	0.10863
A (°C^{-1})	3.81×10^{-3}	3.908×10^{-3}
B (°C^{-2})	-6.02×10^{-7}	-5.775×10^{-7}
C (°C^{-4})	-6.0×10^{-12}	-4.183×10^{-12}

Both β = 0 and C = 0 for T>0°C

RESISTANCE VS TEMPERATURE CURVE



ACCURACY VS TEMPERATURE

HEL-700 platinum RTDs are available in two base resistance trim tolerances: ±0.2% or ±0.1%. The corresponding resistance interchangeability and temperature accuracy for these tolerances are:

Tolerance	Standard ±0.2%		Optional ±0.1%	
Temperature (°C)	±ΔR* (Ω)	±ΔT (°C)	±ΔR* (Ω)	±ΔT (°C)
−200	6.8	1.6	5.1	1.2
−100	2.9	0.8	2.4	0.6
0	2.0	0.5	1.0	0.3
100	2.9	0.8	2.2	0.6
200	5.6	1.6	4.3	1.2
300	8.2	2.4	6.2	1.8
400	11.0	3.2	8.3	2.5
500	12.5	4.0	9.6	3.0
600	15.1	4.8	10.4	3.3

*1000Ω RTD. Divide ΔR by 10 for 100Ω RTD.

NOTICE

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take normal ESD precautions when handling this product.

SPECIFICATIONS

Sensor Type	Thin film platinum RTD; R_0 = 1000 Ω @ 0°C; alpha = 0.00375 Ω/Ω/°C R_0 = 100 Ω @ 0°C; alpha = 0.00385 Ω/Ω/°C
Temperature Range	−200 to +540°C (−300 to +1000°F)
Temperature Accuracy	±0.5°C or 0.8% of temperature, °C (R_0 ±0.2% trim), whichever is greater ±0.3°C or 0.6% of temperature, °C (R_0 ±0.1% trim), whichever is greater (optional)
Base Resistance and Interchangeability, $R_0 \pm \Delta R_0$	1000 ± 2 Ω (±0.2%) @ 0°C 1000 ± 1 Ω (±0.1%) @ 0°C (optional)
Linearity	±0.1% of full scale for temperatures spanning −40 to +125°C ±2.0% of full scale for temperatures spanning −200 to +540°C
Time Constant	<0.15 seconds in water @ 3 ft./sec. <1 second on metal surfaces: <4 seconds in air @ 10 ft./sec.
Operating Current	2 mA max. For self-heating errors of 1°C 1 mA recommended
Stability	Better than 0.25°C/year: 0.05°C/5 years for occupied environments
Self-Heating	0.3 mW/°C
Insulation Resistance	>50 MΩ @ 50 VDC @ 25°C
Case Material	99% alumina support, vapor deposited alumina passified resistance portion, refractory glass passified overall
Lead Material – Ribbon	Platinum ribbon, 0.002 × 0.010 × 0.16 in. long nominal
Lead Pull Strength – Ribbon	200 grams nominal pulling up from surface

FEATURES
- Linear resistance vs temperature
- Accurate and Interchangeable
- Excellent stability
- Teflon or fiberglass lead wires
- Wide temperature range
- Ceramic case material

TYPICAL APPLICATIONS
- HVAC – room, duct and refrigerant equipment
- Instrument and probe assemblies – temperature compensation
- Process control – temperature regulation

HEL-700 Series elements are fully assembled, ready to use directly or in probe assemblies without the need for fragile splices to extension leads.

The 1000Ω, 375 alpha version, provides 10X greater sensitivity and signal-to-noise. Optional NIST calibrations improve accuracy to ±0.03°C at 0°C.

ORDER GUIDE

HEL-705	28 ga. TFE Teflon, 2-wire only
HEL-707	28 ga. Fiberglass, 2-wire only
HEL-711	28 ga. TFE Teflon (2-wire 1000Ω, 3-wire 100Ω)
HEL-712	28 ga. Fiberglass (2-wire 1000Ω, 3-wire 100Ω)
HEL-716	24 ga. TFE Teflon (2-wire 1000Ω, 3-wire 100Ω)
HEL-717	24 ga. Fiberglass (2-wire 1000Ω, 3-wire 100Ω)
-U	1000Ω, 0.00375 Ω/Ω/°C
-T	100Ω, 0.00385 Ω/Ω/°C DIN Standard
-0	±0.2% Resistance Trim (Standard)
-1	±0.1% Resistance Trim (Optional)
-12	Lead wire length, 12 inches
-00	No NIST calibration
-C1	NIST @ 0°C
-C2	NIST @ 0 & 100°C
-C3	NIST @ 0, 100 & 260°C

MOUNTING DIMENSIONS (for reference only)

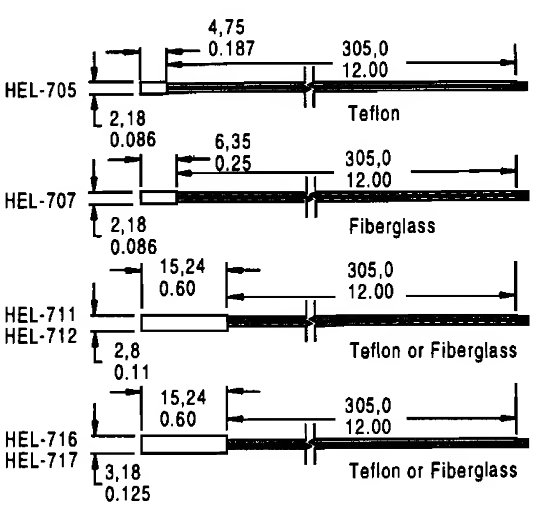


Fig. 1: Wheatstone Bridge 2-Wire Interface

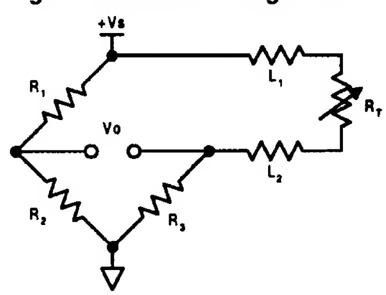


Fig. 2: Linear Output Voltage

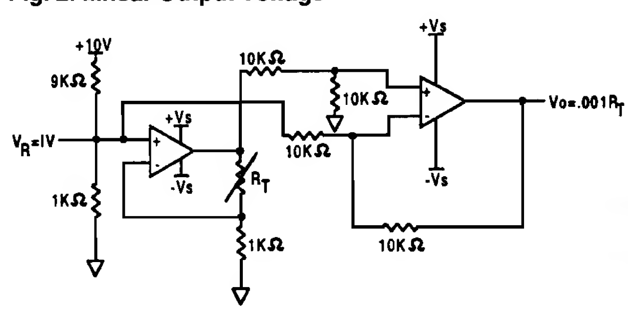
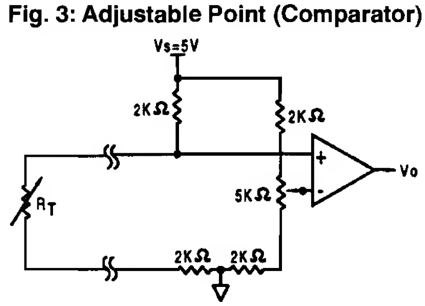


Fig. 3: Adjustable Point (Comparator) Interface



NOTICE
The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take normal ESD precautions when handling this product.

FUNCTIONAL BEHAVIOR

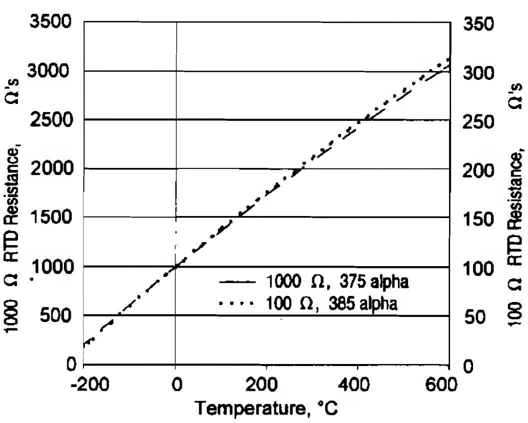
$R_T = R_0(1+AT+BT^2-100CT^3+CT^4)$
RT = Resistance (Ω) at temperature T (°C)
R_0 = Resistance (Ω) at 0°C
T = Temperature in °C
$A = \alpha + \frac{\alpha\,\delta}{100}$ $B = \frac{-\alpha\,\delta}{100^2}$ $C_{T<0} = \frac{-\alpha\,\beta}{100^4}$

CONSTANTS

Alpha, α (°C^{-1})	0.00375 ±0.000029	0.003850 ±0.000010
Delta, δ (°C)	1.605 ± 0.009	1.4999 ± 0.007
Beta, β (°C)	0.16	0.10863
A (°C^{-1})	3.81×10^{-3}	3.908×10^{-3}
B (°C^{-2})	-6.02×10^{-7}	-5.775×10^{-7}
C (°C^{-4})	-6.0×10^{-12}	-4.183×10^{-12}

Both β = 0 and C = 0 for T>0°C

RESISTANCE VS TEMPERATURE CURVE



ACCURACY VS TEMPERATURE

Tolerance	Standard ±0.2%		Optional ±0.1%	
Temperature (°C)	±ΔR* (Ω)	±ΔT (°C)	±ΔR* (Ω)	±ΔT (°C)
−200	6.8	1.6	5.1	1.2
−100	2.9	0.8	2.4	0.6
0	2.0	0.5	1.0	0.3
100	2.9	0.8	2.2	0.6
200	5.6	1.6	4.3	1.2
300	8.2	2.4	6.2	1.8
400	11.0	3.2	8.3	2.5
500	12.5	4.0	9.6	3.0
600	15.1	4.8	10.4	3.3

*1000Ω RTD. Divide Δ by 10 for 100Ω RTD.

NIST CALIBRATION

NIST traceable calibration provides resistance readings at 1, 2 or 3 standard temperature points to yield a resistance versus temperature curve with 10x better accuracy.

Calibration	1 Point	2 Point	3 Point
T (°C)	±ΔT (°C)	±ΔT (°C)	±ΔT (°C)
-200	0.9	—	—
-100	0.5	0.27	0.15
0	0.03	0.03	0.03
100	0.4	0.11	0.07
200	0.8	0.2	0.08
300	1.2	0.33	6.2
400	1.6	0.5	8.3
500	2.0	0.8	9.6
600	2.6	1.2	10.4

SPECIFICATIONS

Sensor Type	Thin film platinum RTD; R_0 = 1000 Ω @ 0°C; alpha = 0.00375 Ω/Ω/°C R_0 = 100 Ω @ 0°C; alpha = 0.00385 Ω/Ω/°C
Temperature Range	TFE Teflon: −200°C to +260°C (−320°F to +500°F) Fiberglass: −75°C to +540°C (−100°F to +1000°F)
Temperature Accuracy	±0.5°C or 0.8% of temperature, °C (R_0 ±0.2% trim), whichever is greater ±0.3°C or 0.6% of temperature, °C (R_0 ±0.1% trim), whichever is greater (optional)
Base Resistance and Interchangeability, $R_0 \pm \Delta R_0$	1000 ± 2 Ω (±0.2%) @ 0°C 1000 ± 1 Ω (±0.1%) @ 0°C (optional)
Linearity	±0.1% of full scale for temperatures spanning −40 to +125°C ±2.0% of full scale for temperatures spanning −75 to +540°C
Time Constant	<0.5 sec. 0.85 inch O.D. in water at 3 ft/sec; <1.0 sec, 0.85 inch O.D. in still water
Operating Current	2 mA maximum for self heating errors of <1°C; 1 mA recommended
Stability	<0.25°C/year; 0.05°C per 5 years in occupied environments
Self Heating	<15 mW/°C for 0.85 O.D. typical
Insulation Resistance	>50 MΩ at 50 VDC at 25°C
Construction	Alumina case; Epoxy potting (Teflon leads); Ceramic potting (fiberglass leads)
Lead Material	Nickel coated stranded copper, Teflon or Fiberglass insulated

FEATURES
- Linear resistance vs temperature
- Accurate and Interchangeable
- Excellent stability
- Small size
- Printed circuit mountable
- Ceramic SIP package

TYPICAL APPLICATIONS
- HVAC – room, duct and refrigerant equipment
- Instrument and probe assemblies
- Electronic assemblies – temperature compensation
- Process control – temperature regulation

HEL-775 platinum RTDs are designed to measure temperatures from −55°C to −150°C (−67°F to 302°F) in printed circuit boards, temperature probes, or other lower temperature applications. Solderable leads in 0.050" or 0.100" spacing provide strong connections for wires or printed circuits.

The 1000Ω, 375 alpha version, provides 10x greater sensitivity and signal-to-noise. The 0.050" lead space models are ideal for probes.

ORDER GUIDE

HEL-775-A	Ceramic SIP pkg. 0.100" lead spacing		
HEL-775-B	Ceramic SIP pkg. 0.050" lead spacing		
	-U	1000Ω, 0.00375 Ω/Ω/°C	
	-T	100Ω, 0.00385 Ω/Ω/°C, DIN specification	
		-0	±0.2% Resistance Trim (Standard)
		-1	±0.1% Resistance Trim (Optional)

MOUNTING DIMENSIONS (for reference only) mm/in.

HEL-775-A **HEL-775-B**

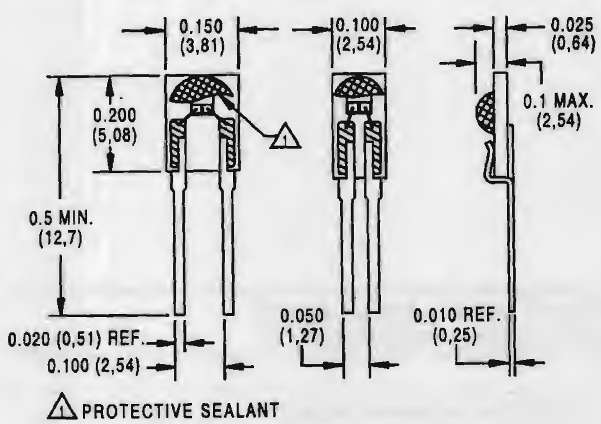


Fig. 1: Wheatstone Bridge 2-Wire Interface

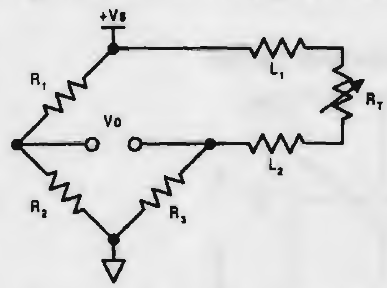


Fig. 2: Linear Output Voltage

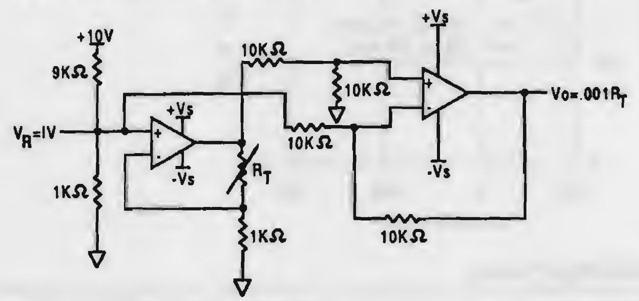
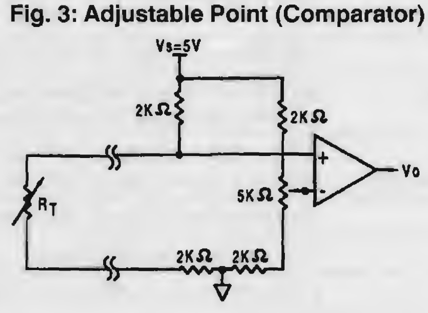


Fig. 3: Adjustable Point (Comparator) Interface



NOTICE
The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take normal ESD precautions when handling this product.

FUNCTIONAL BEHAVIOR

$R_T = R_0(1+AT+BT^2-100CT^3+CT^4)$
RT = Resistance (Ω) at temperature T (°C)
R_0 = Resistance (Ω) at 0°C
T = Temperature in °C

$A = \alpha + \dfrac{\alpha\delta}{100}$ $\quad B = \dfrac{-\alpha\delta}{100^2}$ $\quad C_{T<0} = \dfrac{-\alpha\beta}{100^4}$

Alpha, α (°C^{-1})	0.00375 ±0.000029	0.003850 ±0.000010
Delta, δ (°C)	1.605 ± 0.009	1.4999 ± 0.007
Beta, β (°C)	0.16	0.10863
A (°C^{-1})	3.81×10^{-3}	3.908×10^{-3}
B (°C^{-2})	-6.02×10^{-7}	-5.775×10^{-7}
C (°C^{-4})	-6.0×10^{-12}	-4.183×10^{-12}

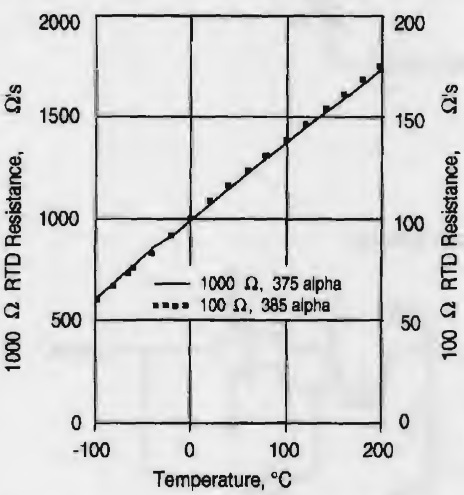
Both β = 0 and C = 0 for T>0°C

ACCURACY VS TEMPERATURE

Tolerance	Standard ±0.2%		Optional ±0.1%	
Temperature (°C)	±ΔR* (Ω)	±ΔT (°C)	±ΔR* (Ω)	±ΔT (°C)
−200	6.8	1.6	5.1	1.2
−100	2.9	0.8	2.4	0.6
0	2.0	0.5	1.0	0.3
100	2.9	0.8	2.2	0.6
200	5.6	1.6	4.3	1.2
300	8.2	2.4	6.2	1.8
400	11.0	3.2	8.3	2.5
500	12.5	4.0	9.6	3.0
600	15.1	4.8	10.4	3.3

* 1000Ω RTD. Divide ΔR by 10 for 100Ω RTD.

RESISTANCE VS TEMPERATURE CURVE



SPECIFICATIONS

Sensor Type	Thin film platinum RTD: R_0 = 1000 Ω @ 0°C; alpha = 0.00375 Ω/Ω/°C R_0 = 100 Ω @ 0°C; alpha = 0.00385 Ω/Ω/°C
Temperature Range	−55°C to +150°C (−67°F to +302°F)
Temperature Accuracy	±0.5°C or 0.8% of temperature, °C (R_0 ±0.2% trim), whichever is greater ±0.3°C or 0.6% of temperature, °C (R_0 ±0.1% trim), whichever is greater (optional)
Base Resistance and Interchangeability, $R_0 \pm \Delta R_0$	1000 ± 2 Ω (±0.2%) @ 0°C or 100 ± 0.2 Ω (±0.2%) @ 0°C 1000 ± 1 Ω (±0.1%) @ 0°C or 100 + 0.2 Ω (+0.2%) @ 0°C (optional)
Linearity	±0.15% of full scale for temperatures spanning −55°C to 150°C
Time Constant	<10 sec. in air at 10 ft./sec.
Operating Current	1 mA maximum in still air for <0.3°C (0.5°F) self heating
Stability	<0.05°C per 5 years in occupied environments
Self Heating HEL-775-A HEL-775-B	 9.7mW/°C nominal in air at 10ft/sec, 4.3mW/°C nominal in enclosed still air 6.8mW/°C nominal in air at 10ft/sec, 3.0mW/°C nominal in enclosed still air
Insulation Resistance	>50 MΩ @ 50 VDC @ 25°C
Construction	Alumina substrate with epoxy protection
Lead Material	Phosphor bronze with bright tin lead 60/40 plating
Lead Configuration	2-wire

HEL-776/HEL-777

FEATURES

- Linear resistance vs temperature
- Accurate and Interchangeable
- Excellent stability
- Small size
- Printed circuit mountable
- Ceramic SIP package

TYPICAL APPLICATIONS

- HVAC – room, duct and refrigerant equipment
- Instrument and probe assemblies
- Electronic assemblies – temperature compensation
- Process control – temperature regulation

HEL-776 and HEL-777 platinum RTDs are designed to measure temperatures from −55°C to −150°C (−67°F to 302°F) in printed circuit boards, temperature probes, or other lower temperature applications. Solderable leads in 0.050" or 0.100" spacing provide strong connections for wires or printed circuits.

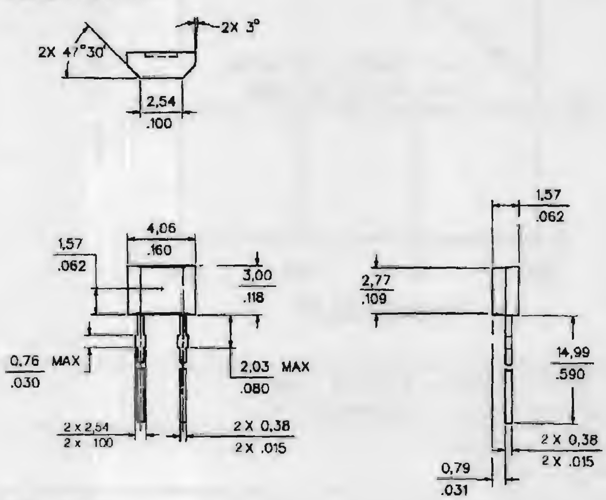
The 1000Ω, 375 alpha version, provides 10x greater sensitivity and signal-to-noise. Both are ideal for air temperature sensing.

ORDER GUIDE

HEL-776-A	Molded SIP pkg. 0.100" lead spacing		
HEL-777-A	Molded SIP pkg. 0.100" lead spacing		
	-U	1000Ω, 0.00375 Ω/Ω/°C	
	-T	100Ω, 0.00385 Ω/Ω/°C	
		-0	±0.2% Resistance Trim (Standard)
		-1	±0.1% Resistance Trim (Optional)

MOUNTING DIMENSIONS (for reference only) mm/in.

HEL-776-A



HEL-777-A

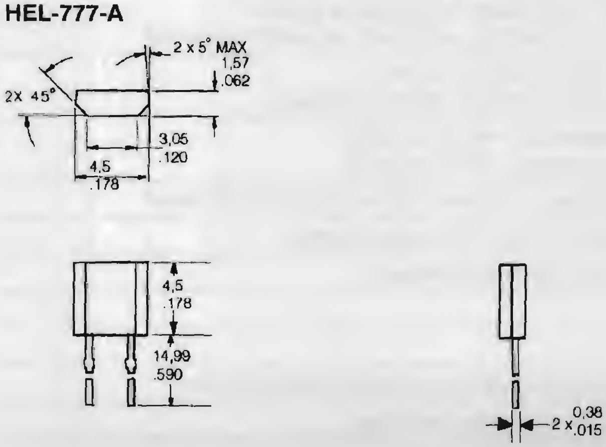


Fig. 1: Wheatstone Bridge 2-Wire Interface

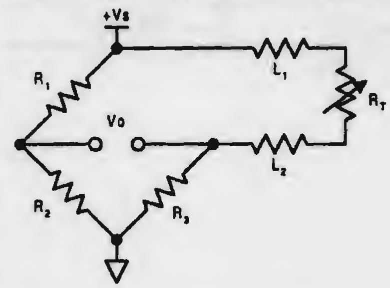


Fig. 2: Linear Output Voltage

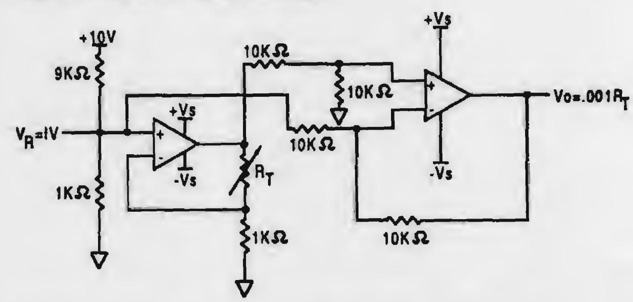
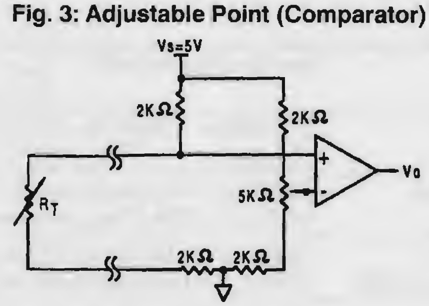


Fig. 3: Adjustable Point (Comparator) Interface



NOTICE

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take normal ESD precautions when handling this product.

Temperature

FUNCTIONAL BEHAVIOR

$R_T = R_0(1+AT+BT^2-100CT^3+CT^4)$
RT = Resistance (Ω) at temperature T (°C)
R_0 = Resistance (Ω) at 0°C
T = Temperature in °C

$A = \alpha + \frac{\alpha\delta}{100}$ $B = \frac{-\alpha\delta}{100^2}$ $C_{T<0} = \frac{-\alpha\beta}{100^4}$

CONSTANTS

Alpha, α (°C⁻¹)	0.00375 ±0.000029	0.003850 ±0.000010
Delta, δ (°C)	1.605 ± 0.009	1.4999 ± 0.007
Beta, β (°C)	0.16	0.10863
A ($°C^{-1}$)	3.81×10^{-3}	3.908×10^{-3}
B ($°C^{-2}$)	-6.02×10^{-7}	-5.775×10^{-7}
C ($°C^{-4}$)	-6.0×10^{-12}	-4.183×10^{-12}

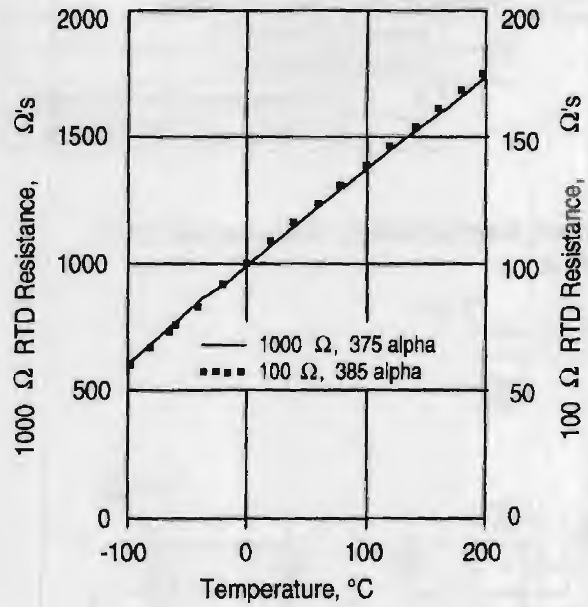
Both β = 0 and C = 0 for T>0°C

ACCURACY VS TEMPERATURE

Tolerance	Standard ±0.2%		Optional ±0.1%	
Temperature (°C)	±ΔR* (Ω)	±ΔT (°C)	±ΔR* (Ω)	±ΔT (°C)
−200	6.8	1.6	5.1	1.2
−100	2.9	0.8	2.4	0.6
0	2.0	0.5	1.0	0.3
100	2.9	0.8	2.2	0.6
200	5.6	1.6	4.3	1.2
300	8.2	2.4	6.2	1.8
400	11.0	3.2	8.3	2.5
500	12.5	4.0	9.6	3.0
600	15.1	4.8	10.4	3.3

* 1000Ω RTD. Divide ΔR by 10 for 100Ω RTD.

RESISTANCE VS TEMPERATURE CURVE



SPECIFICATIONS

Sensor Type	Thin film platinum RTD: R_0 = 1000 Ω @ 0°C; alpha = 0.00375 Ω/Ω/°C R_0 = 100 Ω @ 0°C; alpha = 0.00385 Ω/Ω/°C
Temperature Range	TFE Teflon: −200°C to +260°C (−320°F to +500°F) Fiberglass: −75°C to +540°C (−100°F to +1000°F)
Temperature Accuracy	±0.5°C or 0.8% of temperature °C (R_0 ±0.2% trim), whichever is greater ±0.3°C or 0.6% of temperature °C (R_0 ±0.1% trim), whichever is greater (optional)
Base Resistance and Interchangeability, $R_0 \pm \Delta R_0$	1000 ± 2 Ω (±0.2%) @ 0°C or 100 ± 0.2 Ω (±0.2%) @ 0°C 1000 ± 1 Ω (±0.1%) @ 0°C or 100 ± 0.2 Ω (±0.2%) @ 0°C (optional)
Linearity	±0.1% of full scale for temperatures spanning −40°C to 125°C ±2.0% of full scale for temperatures spanning −75°C to 540°C
Time Constant	<0.5 sec, 0.85 inch O.D. in water at 3 ft/sec; <1.0 sec, 0.85 inch O.D. in still water
Operating Current	2 mA maximum for self heating errors of <1°C; 1 mA recommended
Stability	<0.25°C/year; 0.05°C per 5 years in occupied environments
Self Heating	<15mW/°C for 0.85 O.D. typical
Insulation Resistance	>50 MΩ @ 50 VDC @ 25°C
Construction	Alumina case; Epoxy potting (Teflon leads); Ceramic potting (fiberglass leads)
Lead Material	Nickel coated stranded copper, Teflon or Fiberglass insulated

FEATURES
- Resistance interchangeable
- Accurate
- Linear
- Fast
- Laser trimmed
- Bolt, cement-on or strap-on models

TYPICAL APPLICATIONS
- HVAC – room, duct and refrigerant equipment
- OEM assemblies
- Electronic assemblies – semiconductor protection, temperature compensation
- Process control – temperature regulation

The HRTS is designed to measure surface temperatures from −200 to +480°C (−320 to +900°F) in printed circuit, temperature probe, or other applications.

HRTS surface temperature sensors are fully assembled elements, ready to use, without the need for fragile splices to extension leads.

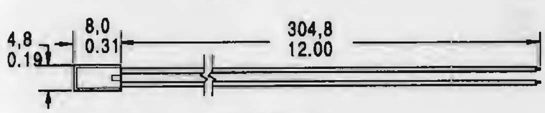
A thin layer of platinum is deposited on an alumina subsstrate and laser trimmed to a resistance interchangeability of ±0.2% with ±0.5°C accuracy or ±0.1% with ±0.3°C accuracy. The sensor chip is then glassed, wired and potted or ceramic fired to result in a cylindrical alumina package with either Teflon or fiber glass insulated lead wires.

ORDER GUIDE

HRTS-5760-B	Miniature, ceramic body, 28 ga TFE Teflon insulated leads (2-wire only)			
HRTS-61	Bolt-on, nickel plated copper alloy body, 24 ga fiberglass insulated leads, SST braid, TFE overwrap, spiral armor			
	-T	100Ω, 0.00385 Ω/Ω/°C, 3-wire leads, DIN specification		
	-U	1000Ω, 0.00375 Ω/Ω/°C, 2-wire leads		
		-0	±0.2% Resistance Trim (Standard)	
		-1	±0.1% Resistance Trim (Optional)	
			-12	Standard length, HRTS-5760-B
			-24	Standard length, HRTS-61

MOUNTING DIMENSIONS (for reference only)

HRTS-5760-B



HRTS-61

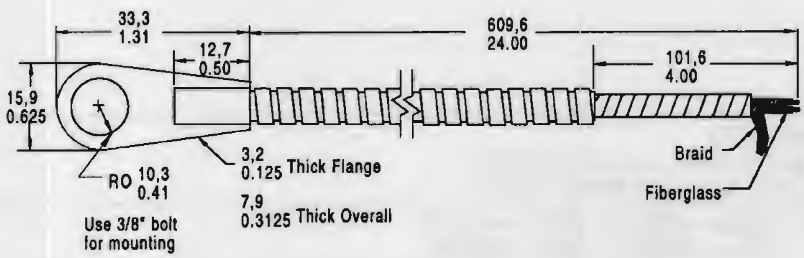


Fig. 1: Wheatstone Bridge 2-Wire Interface

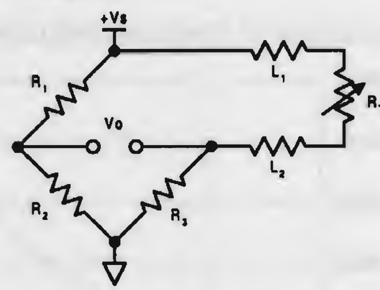


Fig. 2: Linear Output Voltage

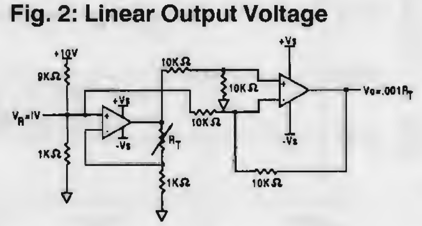
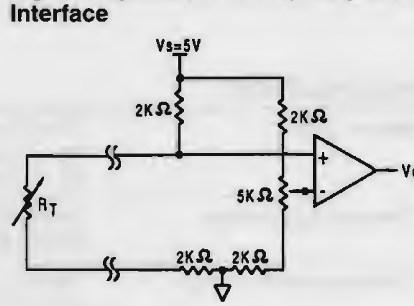


Fig. 3: Adjustable Point (Comparator) Interface



FUNCTIONAL BEHAVIOR

$R_T = R_0(1+AT+BT^2-100CT^3+CT^4)$
RT = Resistance (Ω) at temperature T (°C)
R_0 = Resistance (Ω) at 0°C
T = Temperature in °C

$A = \alpha + \frac{\alpha\delta}{100}$ $B = \frac{-\alpha\delta}{100^2}$ $C_{T<0} = \frac{-\alpha\beta}{100^4}$

CONSTANTS

Alpha, α (°C^{-1})	0.00375 ±0.000029	0.003850 ±0.000010
Delta, δ (°C)	1.605 ± 0.009	1.4999 ± 0.007
Beta, β (°C)	0.16	0.10863
A (°C^{-1})	3.81×10^{-3}	3.908×10^{-3}
B (°C^{-2})	-6.02×10^{-7}	-5.775×10^{-7}
C (°C^{-4})	-6.0×10^{-12}	-4.183×10^{-12}

Both β = 0 and C = 0 for T>0°C

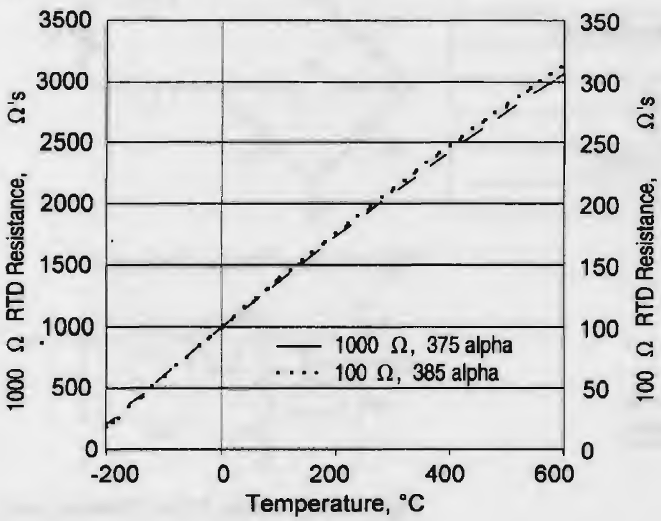
ACCURACY VS TEMPERATURE

HRTS platinum RTDs are available in two base resistance trim tolerances: ±0.2% or ±0.1%. The corresponding resistance interchangeability and temperature accuracy for these tolerances are:

Tolerance	Standard ±0.2%		Optional ±0.1%	
Temperature (°C)	±ΔR* (Ω)	±ΔT (°C)	±ΔR* (Ω)	±ΔT (°C)
−200	6.8	1.6	5.1	1.2
−100	2.9	0.8	2.4	0.6
0	2.0	0.5	1.0	0.3
100	2.9	0.8	2.2	0.6
200	5.6	1.6	4.3	1.2
300	8.2	2.4	6.2	1.8
400	11.0	3.2	8.3	2.5
500	12.5	4.0	9.6	3.0
600	15.1	4.8	10.4	3.3

*1000Ω RTD. Divide ΔR by 10 for 100Ω RTD.

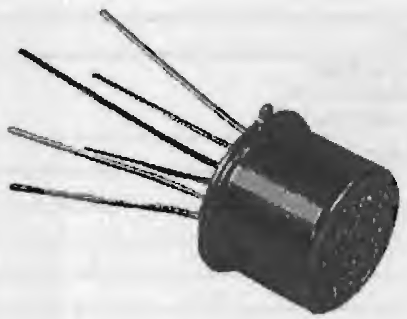
RESISTANCE VS TEMPERATURE CURVE



NOTICE
The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take normal ESD precautions when handling this product.

SPECIFICATIONS

Sensor Type	Thin film platinum RTD: R_o = 1000 Ω @ 0°C; alpha = 0.00375 Ω/Ω/°C R_o = 100 Ω @ 0°C; alpha = 0.00385 Ω/Ω/°C
Temperature Range	HRTS-5760-B: −200 to +260°C (−320 to +500°F) HRTS-61: −75 to +425°C (−100 to +800°F)
Temperature Accuracy	±0.5°C or 0.8% of temperature @ 0.2% R_o Trim ±0.3°C or 0.6% of temperature @ 0.1% R_o Trim Optional
Time Constant, 1/e	HRTS-5760-B: Typically 0.6 sec. on metal surfaces HRTS-61: Typically 20 sec. On metal surfaces
Operating Current	2 mA max. for self-heating errors of 1°C 1 mA recommended
Self-Heating	0.3 mW/°C
Lead Material	Nickel coated stranded copper, Teflon or Fiberglass insulated



FEATURES

- Linear voltage output vs %RH
- Laser trimmed interchangeability
- High accuracy, fast response
- Chemically resistant
- Stable, low drift performance
- Built-in static protection
- Ideal for dew point and absolute moisture measurements
- TO-39 housing

TYPICAL APPLICATIONS

- Refrigeration
- Drying
- Meteorology
- Battery-powered systems
- OEM assemblies

GENERAL INFORMATION

HIH-3602-A and HIH-3602-C Relative Humidity (RH) / Moisture sensors combine both relative humidity and temperature sensing in a TO-5 housing with a hydrophobic sintered stainless steel filter

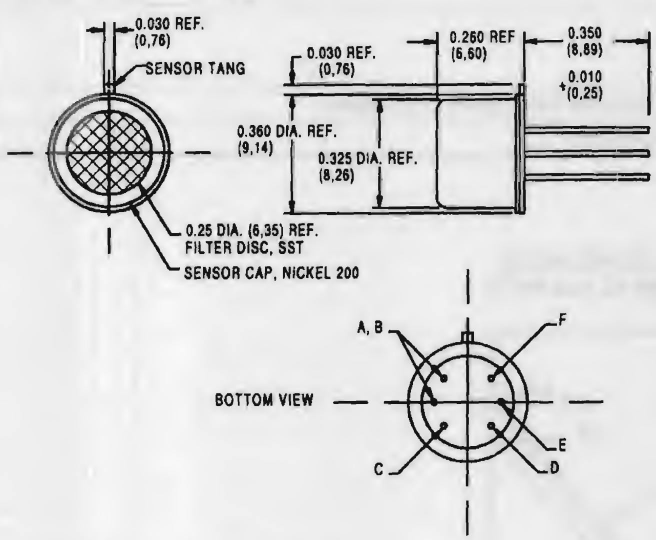
The laser trimmed thermoset polymer capacitive sensing elements have on-chip integrated signal conditioning. The temperature sensor is thermally connected with the RH sensor making the HIH-3602-A/C ideal for measuring dew point and other absolute moisture terms. Factory calibration data supplied with each sensor allows individually matched downstream electronics and ±2% RH total accuracy.

ORDER GUIDE

Catalog Listing	Description
HIH-3602-A	Monolithic IC humidity sensor with integral thermistor in TO-5 can
HIH-3602-C	Monolithic IC humidity sensor with integral precision RTD in TO-5 can

MOUNTING DIMENSIONS (for reference only)

HIH-3602-A and HIH-3602-C

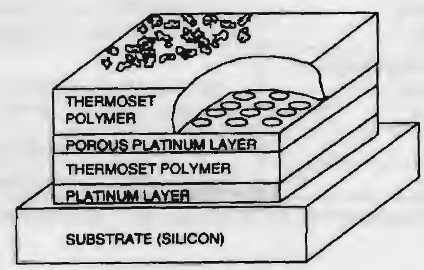


NIST CALIBRATION

Each HIH-3602-A or HIH-3602-C sensor includes a sensor specific NIST calibration and data printout. Sensors are not individually serialized.

RH SENSOR CONSTRUCTION

Sensor construction consists of a planar capacitor with a second polymer layer to protect against dirt, dust, oils and other hazards.



NOTICE

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take normal ESD precautions when handling this product.

INTERNAL PIN CONNECTIONS

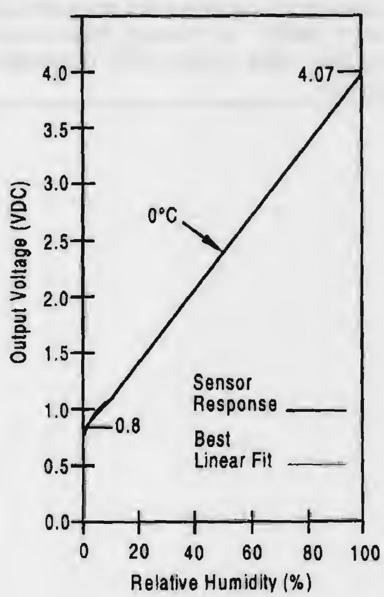
0.018 (0,46) dia. lead gold plated (6 places)	
A, B	(HIH-3602-A) Thermistor for temperature compensation
A, B	(HIH-3602-C) RTD for temperature compensation
C	+VDC supply
D	(−) Power or ground
E	VDC out
F	Case ground

PERFORMANCE SPECIFICATIONS

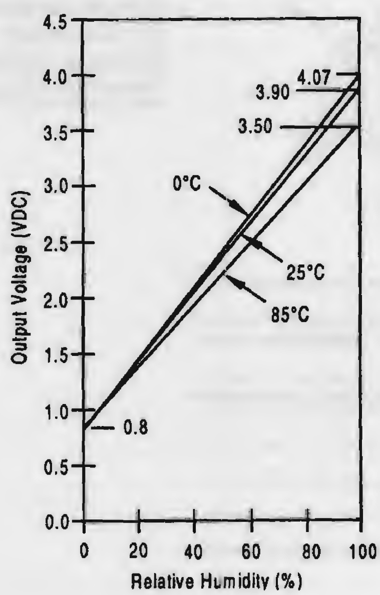
Catalog Listing	HIH-3602-A	HIH-3602-C
Temperature Sensor	Rb = 100 kΩ ±5% @ 25°C, NTC 0-50°C, β = 4143K, T = °K R(T) = Rb exp (β/T-β/298.15)	1000Ω ±0.2% @ 0°C Thin Film Platinum RTD alpha = 0.00375 Ω/Ω/°C
Temperature Accuracy	±3.0°C @ 25°C	±0.5°C @ 25°C
RH Accuracy[1]	±2% RH, 0-100% RH non-condensing, 25°C, V_{supply} = 5 VDC	
RH Interchangeability	±5% RH, 0-60% RH; ±8% @ 90% RH	
RH Linearity	±0.5% RH typical	
RH Hysteresis	±1.2% of RH span maximum	
RH Repeatability	±0.5% RH	
RH Response Time, 1/e	50 sec in slowly moving air at 25°C	
RH Stability	±1% RH typical at 50% RH in 5 years	
Power Requirements Voltage Supply Current Supply	 4 to 5.8 VDC, sensor calibrated at 5 VDC 200 μA at 5 VDC, 2 mA typical at 9 VDC	
Voltage Output V_{supply} = 5 VDC Drive Limits	$V_{out} = V_{supply}$ (0.0062 (Sensor RH) +0.16), typical @ 25°C (Data printout provides a similar, but sensor specific, equation at 25°C.) 0.8 to 3.9 VDC output @ 25°C typical Push/pull symmetric; 50 μA typical, 20 μA minimum, 100 μA maximum Turn-on ≤0.1 second	
Temp. Compensation Effect @ 0% RH Effect @ 100% RH	True RH = (Sensor RH)/(1.093-.0012T), T in °F True RH = (Sensor RH)/(1.0546-0.00216T), T in °C ±0.007% RH/°C (negligible) −0.22% RH/°C (<1% RH effect typical in occupied space systems above 15°C (59°F))	
Humidity Range Operating Storage	 0 to 100% RH, non-condensing[1] 0 to 90% RH, non-condensing	
Temperature Range Operating Storage	 −40°C to 85°C (−40°F to 185°F) −40°C to 125°C (−40°F to 275°F)	
Package	TO-5 with 60μ hydrophobic sintered stainless steel filter, resists condensation	
Handling	Static sensitive diode protected to 15 kV maximum	

1. Extended exposure to ≥90% RH causes a reversible shift of 3% RH.

OUTPUT VOLTAGE VS RELATIVE HUMIDITY (at 0°C)



OUTPUT VOLTAGE VS RELATIVE HUMIDITY (at 0°C, 25°C, and 85°C)



FEATURES
- Linear voltage output vs %RH
- Laser trimmed interchangeability
- High accuracy
- Fast response
- Stable, low drift performance
- Chemically resistant
- Built-in static protection

TYPICAL APPLICATIONS
- Refrigeration
- Drying
- Meteorology
- Battery-powered systems
- OEM assemblies

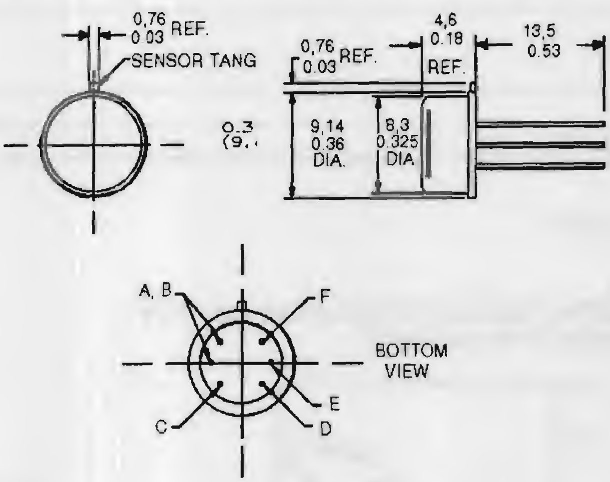
GENERAL INFORMATION
The HIH-3602-L IC (Integrated Circuit) Relative Humidity (RH) sensor delivers instrumentation quality RH sensing performance in a rugged, low cost, slotted TO-39 housing.

The RH sensor is a thermoset polymer capacitive sensing element with on-chip integrated signal conditioning. On-board signal conditioning reduces product development times while a typical current draw of only 200 μA makes the HIH-3602-L perfect for battery powered systems.

ORDER GUIDE

Catalog Listing	Description
HIH-3602-L	Integrated circuit humidity sensor in TO-39 can
HIH-3602-L-CP	Integrated circuit humidity sensor in TO-39 can with calibration and data printout

MOUNTING DIMENSIONS (for reference only)

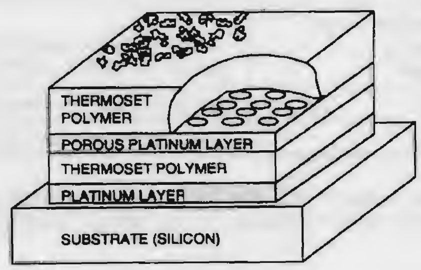


INTERNAL PIN CONNECTIONS

0.018 (0,46) dia. lead gold plated (6 places)	
A, B	No connection
C	+VDC supply
D	(−) Power or ground
E	VDC out
F	Case ground

NIST CALIBRATION
HIH-3602-L may be ordered with a NIST calibration and sensor specific data printout. Append "−CP" to the model number to order.

RH SENSOR CONSTRUCTION
Sensor construction consists of a planar capacitor with a second polymer layer to protect against dirt, dust, oils and other hazards.



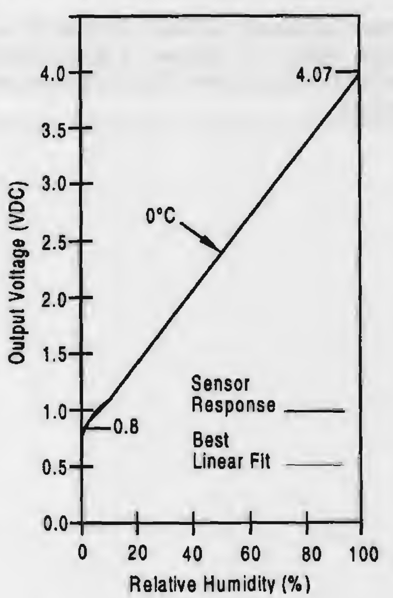
NOTICE
The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take normal ESD precautions when handling this product.

PERFORMANCE SPECIFICATIONS

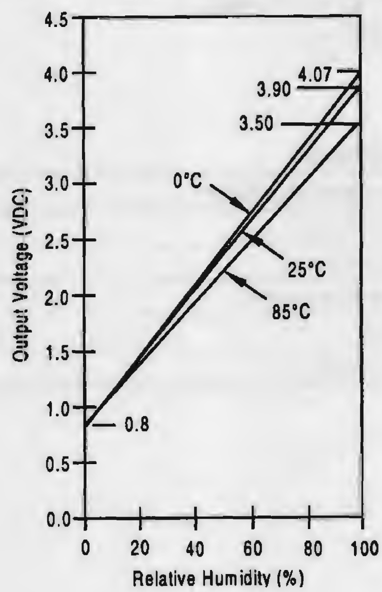
Parameter	Conditions
RH Accuracy[1]	±2% RH, 0-100% RH non-condensing, 25°C, V_{supply} = 5 VDC
RH Interchangeability	±5% RH, 0-60% RH; ±8% @ 90% RH typical
RH Linearity	±0.5% RH typical
RH Hysteresis	±1.2% of RH span maximum
RH Repeatability	±0.5% RH
RH Response Time, 1/e	30 seconds in slowly moving air at 25°C
RH Stability	±1% RH typical at 50% RH in 5 years
Power Requirements Voltage Supply Current Supply	 4 to 5.8 VDC, sensor calibrated at 5 VDC 200 µA at 5 VDC, 2 mA typical at 9 VDC
Voltage Output V_{supply} = 5 VDC Drive Limits	V_{out} = V_{supply} (0.0062 (Sensor RH) +0.16), typical @ 25°C (Data printout provides a similar, but sensor specific, equation at 25°C.) 0.8 to 3.9 VDC output @ 25°C typical Push/pull symmetric; 50 µA typical, 20 µA minimum, 100 µA maximum Turn-on ≤0.1 second
Temp. Compensation Effect @ 0% RH Effect @ 100% RH	True RH = (Sensor RH)/(1.093-.0012T), T in °F True RH = (Sensor RH)/(1.0546-0.00216T), T in °C ±0.007% RH/°C (negligible) −0.22% RH/°C (<1% RH effect typical in occupied space systems above 15°C (59°F))
Humidity Range Operating Storage	 0 to 100% RH, non-condensing 0 to 90% RH, non-condensing[1]
Temperature Range Operating Storage	 −40°C to 85°C (−40°F to 185°F) −40°C to 125°C (−40°F to 257°F)
Package	Six pin TO-39 with slotted nickel cap[2]
Handling	Static sensitive, diode protected to 15 kV maximum

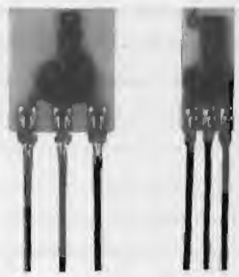
Notes:
1. Extended exposure to ≥90% RH causes a reversible shift of 3% RH.
2. This sensor is light sensitive. For best results, shield the sensor from bright light.

OUTPUT VOLTAGE VS RELATIVE HUMIDITY (at 0°C)



OUTPUT VOLTAGE VS RELATIVE HUMIDITY (at 0°C, 25°C, and 85°C)





FEATURES
- Linear voltage output vs %RH
- Laser trimmed interchangeability
- Low power design
- High accuracy
- Fast response time
- Stable, low drift performance
- Chemically resistant

TYPICAL APPLICATIONS
- Refrigeration
- Drying
- Meteorology
- Battery-powered systems
- OEM assemblies

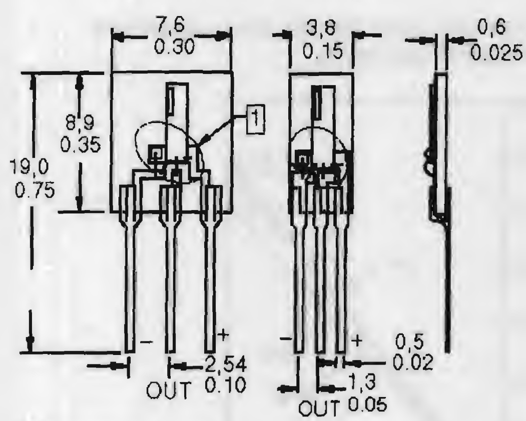
GENERAL INFORMATION
The HIH-3605 monolithic IC (Integrated Circuit) humidity sensor is designed specifically for high volume OEM (Original Equipment Manufacturer) users. Direct input to a controller or other device is made possible by this sensor's linear voltage output. With a typical current draw of only 200 μA, the HIH-3605 is ideally suited for low drain, battery powered systems.

The HIH-3605 delivers instrumentation quality RH sensing performance in a low cost, solderable SIP (Single In-line Package). Available in two lead spacing configurations, the RH sensor is a laser trimmed thermoset polymer capacitive sensing element with on-chip integrated signal conditioning.

ORDER GUIDE

Catalog Listing	Description
HIH-3605-A	Integrated circuit humidity sensor, 0.100 in. lead pitch SIP
HIH-3605-A-CP	Integrated circuit humidity sensor, 0.100 in. lead pitch SIP with calibration and data printout
HIH-3605-B	Integrated circuit humidity sensor, 0.050 in. lead pitch SIP
HIH-3605-B-CP	Integrated circuit humidity sensor, 0.050 in. lead pitch SIP with calibration and data printout.

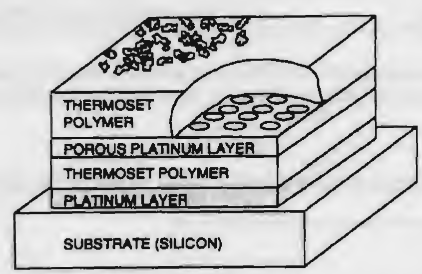
MOUNTING DIMENSIONS (for reference only)



1 Protective Sealant

NIST CALIBRATION
HIH-3605 sensors may be ordered with a NIST calibration and sensor specific data printout. Append "−CP" to the model number to order.

RH SENSOR CONSTRUCTION
Sensor construction consists of a planar capacitor with a second polymer layer to protect against dirt, dust, oils and other hazards.



NOTICE

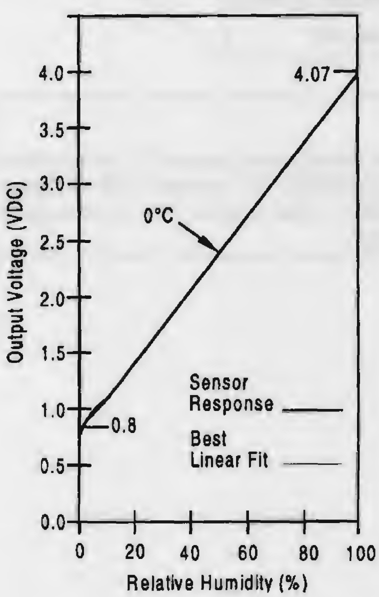
The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take normal ESD precautions when handling this product.

PERFORMANCE SPECIFICATIONS

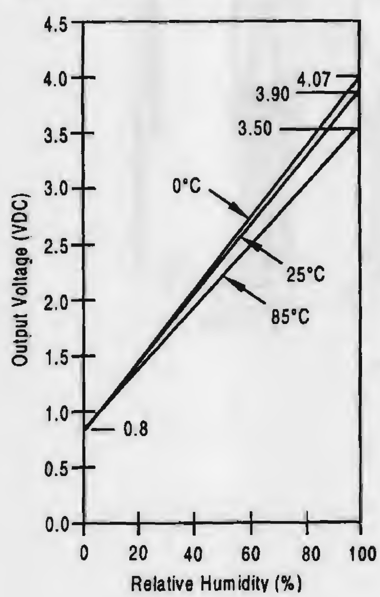
Parameter	Conditions
RH Accuracy[1]	±2% RH, 0-100% RH non-condensing, 25°C, V_{supply} = 5 VDC
RH Interchangeability	±5% RH, 0-60% RH; ±8% @ 90% RH typical
RH Linearity	±0.5% RH typical
RH Hysteresis	±1.2% of RH span maximum
RH Repeatability	±0.5% RH
RH Response Time, 1/e	15 sec in slowly moving air at 25°C
RH Stability	±1% RH typical at 50% RH in 5 years
Power Requirements Voltage Supply Current Supply	 4 to 5.8 VDC, sensor calibrated at 5 VDC 200 µA at 5 VDC, 2 mA typical at 9 VDC
Voltage Output V_{supply} = 5 VDC Drive Limits	V_{out} = V_{supply} (0.0062 (Sensor RH) +0.16), typical @ 25°C (Data printout provides a similar, but sensor specific, equation at 25°C.) 0.8 to 3.9 VDC output @ 25°C typical Push/pull symmetric; 50 µA typical, 20 µA minimum, 100 µA maximum Turn-on ≤0.1 second
Temp. Compensation Effect @ 0% RH Effect @ 100% RH	True RH = (Sensor RH)/(1.093-.0012T), T in °F True RH = (Sensor RH)/(1.0546-0.00216T), T in °C ±0.007% RH/°C (negligible) −0.22% RH/°C (<1% RH effect typical in occupied space systems above 15°C (59°F))
Humidity Range Operating Storage	 0 to 100% RH, non-condensing[1] 0 to 90% RH, non-condensing
Temperature Range Operating Storage	 −40°C to 85°C (−40°F to 185°F) −51°C to 125°C (−60°F to 257°F)
Package[2]	Three pin solderable ceramic SIP
Handling	Static sensitive diode protected to 15 kV maximum

Notes:
1. Extended exposure to ≥90% RH causes a reversible shift of 3% RH.
2. This sensor is light sensitive. For best results, shield the sensor from bright light.

OUTPUT VOLTAGE VS RELATIVE HUMIDITY (at 0°C)



OUTPUT VOLTAGE VS RELATIVE HUMIDITY (at 0°C, 25°C, and 85°C)



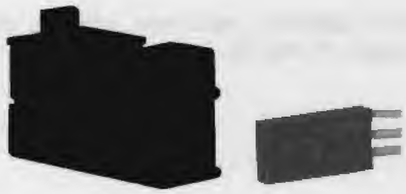
Solid State Sensors
Integral Magnet Position Sensors

GENERAL INFORMATION
MICRO SWITCH combines digital Hall effect sensors with integral magnets to produce the VX series mechanically operated solid state sensors.

- The VX series features a permanent magnet mounted on the plastic plunger which operates a digital Hall effect sensor. When actuated, the sensor produces a sinking output. Mounting dimensions and mechanical characteristics are similar to MICRO SWITCH's popular V3 and V7 electromechanical snap-action switch series. The VX series features AMP plug-in connectors.
- The AV vane sensors consist of a magnet and a Hall effect sensor in a rugged plastic housing. When a ferrous vane is passed through the gap between the Hall sensor and the magnet, the magnetic flux is shunted away from the sensor causing the output to change state. (For more information on vane sensors including actuation and mechanical characteristics, see page 50.)
- GT1 sense small ferrous metal targets and are popular as geartooth sensors. Page 52.

For absolute maximum ratings, see pages 75 and 76.

Integral Magnet



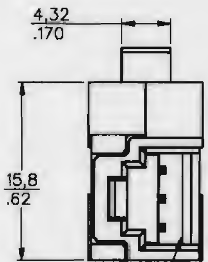
FEATURES

- Plunger operated non-contact digital output
- Low force operation
- −40° to +70°C operating temperature
- Direct interface to solid state circuits
- Reverse voltage protection
- Rugged construction
- Tested to over 100 million operations
- Wide variety of standard levers and actuators available
- Lever external to switch body
- Industry standard mounting holes
- No external terminals — uses standard keyed and locking plug-in connectors
- UL recognized, CSA certified
- Plunger is acetal copolymer. Housing is PBT polyester.

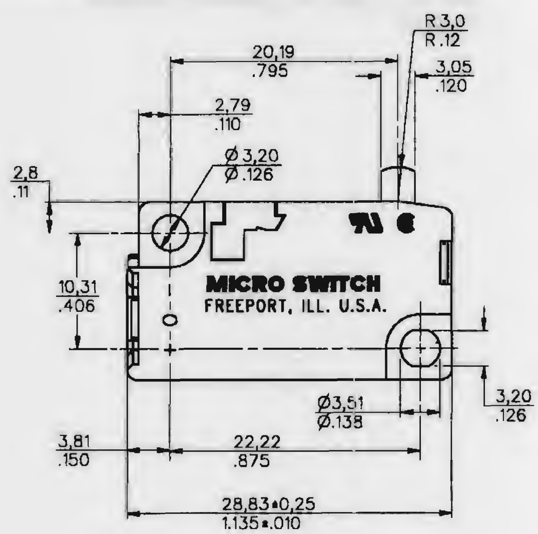
ELECTRICAL SPECIFICATIONS

Supply Voltage (VDC)	4.5 to 24
Supply Current (mA max.)	15
Output Type	Sink
Current per Output (mA)	10

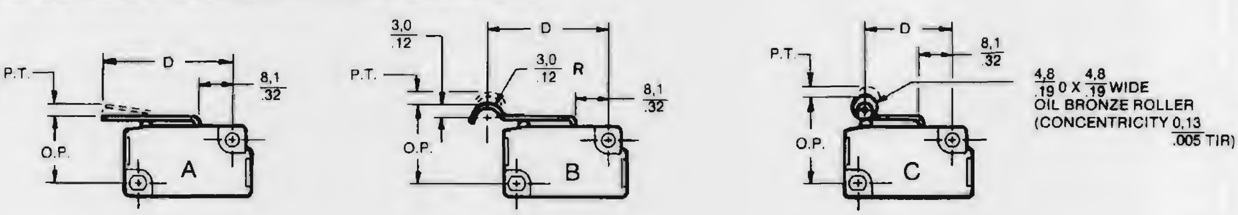
MOUNTING DIMENSIONS (For reference only)



ACCEPTS AMP CONNECTOR 102241-1 OR EQUIVALENT



OPERATING CHARACTERISTICS DIMENSIONS



Solid State Sensors
Solid State Basic Switch

Characteristics: P.T. — Pretravel; O.T. — Overtravel; D.T. — Differential Travel; O.P. — Operating Position

VX ORDER GUIDE

Catalog Listings Accepts AMP Conn.	Operating Force Ounces Newtons	Lever Actuation Point (D)	Lever Style*	P.T. max mm inches	O.T. min. mm inches	D.T. max. mm inches	O.P. mm inches
VX10	.35 + .18 (−.14) 0,1 (+,05,−,04)	—	—	2,16 .085	1,02 .040	0,30 .012	14,73 ± 0,51 .580 ± .020
VX80	3.0 ± .88 0,83 ± ,24	—	(Pin Plunger)				
VX10-A1	.35 ± .2 0,1 ± ,06	21,8 .860	A (Short)	2,59 .102	1,02 .040	0,36 .014	15,37 ± 0,69 .605 ± .027
VX80-A1	2.8± 1.1 ,78 ± ,31						
VX10-A2	0.2 ± .1 ,06 ± ,03	35,6 1.400	A (Medium)	5,33 .210	2,16 .085	0,71 .028	15,34 ± 1,40 .604 ± .055
VX80-A2	1.41 ± .50 ,39 ± ,14						
VX10-A3	.10 ± .07 ,03 ± ,02	59,4 2.340	A (Long)	9,96 .392	4,06 .160	1,32 .052	15,24 ± 2,64 .600 ± .104
VX80-A3	.75 + .35 (−.25) ,21 (+0,1−,07)						
VX10-B1	0.20 + .15 (−.10) ,06 (+,04−,03)	32,6 1.285	B (Simulated Roller)	5,21 .205	1,91 .075	0,64 .025	18,52 ± 1,47 .729 ± .058
VX80-B1	1.55 ± .53 ,43 ± ,15						
VX10-C1	.40 ± .20 ,11 ± ,06	20,6 .810	C (Short Roller)	2,49 .098	1,02 .040	0,33 .013	20,68 ± 0,69 .814 ± .027
VX80-C1	3.0 ± 1.06 ,83 ± ,29						

* Other lever styles are available. Contact MICRO SWITCH sales office.

Termination

Terminal pins accept AMP connectors (not furnished):

AMP 102241-1
MICRO SWITCH part number:
VX1A — connector & receptacle unassembled.
VX1A-01 — connector & receptacle pre-assembled with 5.4", 24 gauge lead wires.

NOTE: The output transistors of the listings shown are "normally off." They are not conducting and the output voltage is High with plunger in free position. To order devices which are "normally on" and the output voltage is Low (conducting with plunger in free position), change the second digit from 0 to a 1, or a 2 to a 3 in the catalog listing.

Example: VX10-A1 — VX11-A1

Integral Magnet

Solid State Sensors
Hall Effect Vane Position Sensor

FEATURES
- Protection against random voltage spikes
  - electrical transients up to +80 volts
  - reverse power supply to −80 volts
- Stainless steel mounting studs lock sensor in place
- Vane depth of 17,2 mm (.68 in.) allows flexibility in actuator placement
- Operating temperature range of −40 to +150°C
- 22 mA current consumption
- 4.5 to 24 VDC supply voltage range
- Current sinking output
- High output current capability up to 40 mA absolute maximum

GENERAL INFORMATION
2AV Series Hall effect vane position sensors are specifically designed to translate the relative position of a ferrous metal actuator into a digital electronic signal. The Hall effect integrated circuit and the magnet are in a rugged plastic housing. When a ferrous metal actuator passes between them, the magnetic flux is shunted away from the sensor. This causes the output signal to change state.

ORDER GUIDE

Catalog Listing	Description
2AV54	Current sinking Hall effect vane sensor

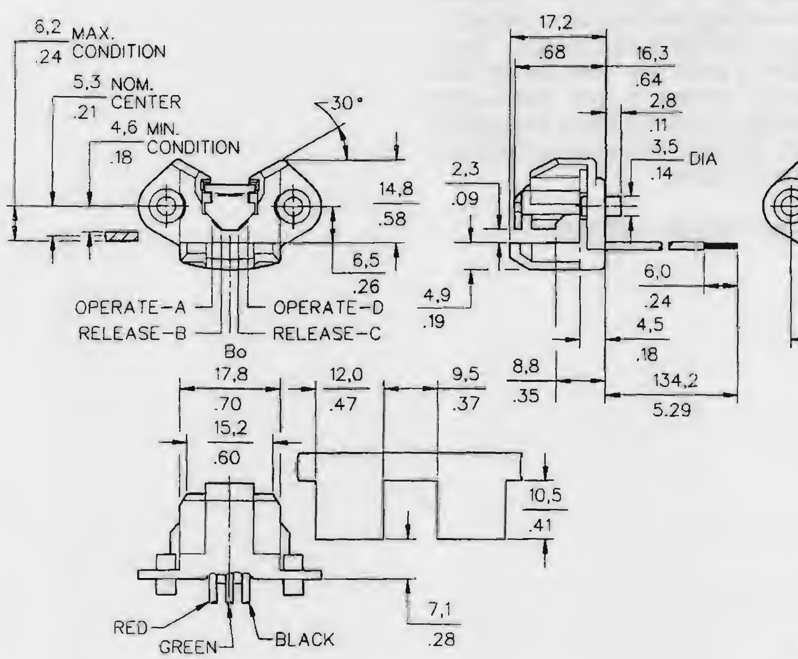
MECHANICAL CHARACTERISTICS

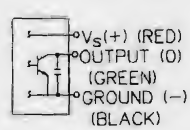
Operating Range	Left or Right Operate	Release	Diff.	Differential L to R, R to L	
12 VDC, 25°C	1,19±,30	−1,04±,33	0,38±,33	2,21±,64	mm
	.047±.012	−.041±.013	.015±.013	.087±.025	in.

ENVIRONMENTAL CHARACTERISTICS

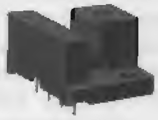
Vibration	45 G per MIL-STD-202, Method 204, condition E
Humidity	Up to 500 hours @ 85°C, 80% RH
Salt spray	48 hours per IEC-68-2-11
Temperature shock	250 air-to-air shocks @ −40° to +130°C

MOUNTING DIMENSIONS (for reference only)





Solid State Sensors
Hall Effect Vane Position Sensors



FEATURES
- Operated by vane interrupter
- −40 to +125°C temperature range
- Current sinking output
- Smaller size than 2AV
- Four pin in-line printed circuit board terminals or leadwires
- Closely controlled differential to predict pulse width
- 4.5 to 5.5 or 6 to 16 VDC power supply

4AV ORDER GUIDE

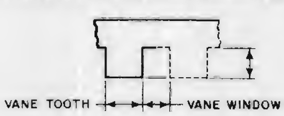
Catalog Listings	4AV11C	4AV12C	4AV11A	4AV12A
Supply Voltage (VDC)	4.5 to 5.5	4.5 to 5.5	6 to 16	6 to 16
Supply Current (mA max.)	7.0	7.0	13.0	13.0
Output Type	Sink	Sink	Sink	Sink
Output Voltage (V)	0.4	0.4	0.4	0.4
Current per Output (mA)	4	8	10	20
Termination	PC Board	Leadwire	PC Board	Leadwire

AV MECHANICAL CHARACTERISTICS

Series	Left Operate a	Mag. Release b	Slope Diff.	Right Operate d	Release c	Diff.	L-R Diff.
4AV*	5,4/.213	6,0/.237	0,6/.024	8,6/.337	7,9/.313	0,6/.024	2,5/.100

* Operating characteristics of the 4AV are adjusted to produce a .100±.010 dimension between the operate point on one side of the switch, to the release point on the other side. The actuator can be designed to produce a specific pulse width for timing or sequencing operations.

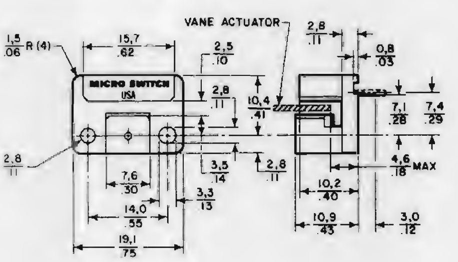
VANE DIMENSIONS (mm/in.)

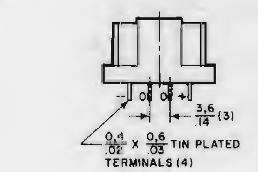


Thickness	Min. Window	Min. Tooth	Min. Tooth Depth
1,0/.04	10,2/.40	10,2/.40	9,3/.37
1,6/.06	10,2/.40	6,3/.25	

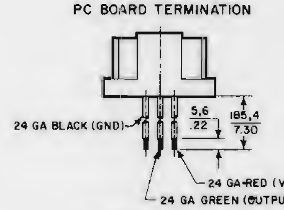
Vane material:
Cold rolled steel, 1018 or low in carbon (annealed).

MOUNTING DIMENSIONS (For reference only)



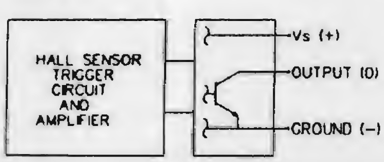


PC BOARD TERMINATION

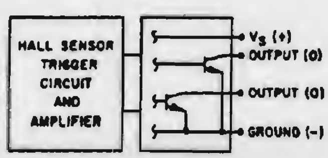


LEADWIRE TERMINATION

BLOCK DIAGRAM
Leadwire



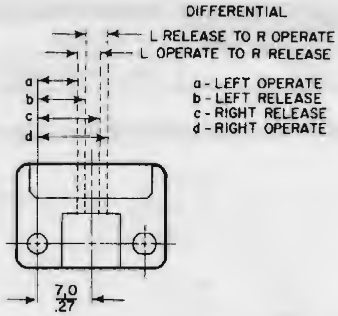
PC Board



GENERAL INFORMATION
AV vane operated integral magnet position sensors are operated by passing a ferrous vane through the gap between the Hall sensor and the magnet, shunting the magnetic flux away from the sensor. AVs can be used as limit switches by operating with a single large vane; as tachometer sensors by using toothed wheels; or as synchronizing elements by using cams or sectors. AV Series have many features in common such as:

- Operation by a low cost, easy to fabricate ferrous vane
- Magnet and sensor incorporated in same rugged package
- Sealed construction . . . unaffected by dust or dirt
- 0 to 100 kHz operating speed . . . no minimum speed of operation
- On and Off times programmable by vane dimensioning
- Precision mechanical operating characteristics

VANE OPERATION



1. With no vane in the gap the output is conducting (Sinking is Low, Sourcing is High).
2. Vane movement from left to right. When leading edge reaches "b", the output stops conducting (Sinking goes High, Sourcing goes Low).
3. **After leading edge reaches "b":**
   A. If the vane moves on through the gap; when the trailing edge reaches "d", the output will be conducting.
   B. If direction of vane travel **reverses;** "a", output will be conducting.
4. For vane movement from right to left, output is non-conducting when the leading edge reaches "c", and is conducting when the trailing edge reaches "a".

Solid State Sensors
Hall Effect Gear Tooth Sensors

TYPICAL APPLICATIONS
Automotive and Heavy Duty Vehicles:
- Camshaft and crankshaft speed/ position
- Transmission speed
- Tachometers
- Anti-skid/traction control

Industrial:
- Sprocket speed
- Chain link conveyor speed and distance
- Stop motion detector
- High speed low cost proximity
- Tachometers, Counters

GT1 ORDER GUIDE

Catalog Listing	Description
1GT101DC	Gear Tooth Sensor

FEATURES
- Senses ferrous metal targets
- Digital current sinking output (open collector)
- Better signal-to-noise ratio than variable reluctance sensors, excellent low speed performance, output amplitude not dependent on RPM
- Sensor electronically *self-adjusts* to slight variations in runout and variations in temperature, simplifying installation and maintenance
- Fast operating speed – over 100 kHz
- EMI resistant
- Reverse polarity protection and transient protection (integrated into Hall I.C.)
- Wide continuous operating temperature range (−40° to 150°C), short term to 160°C

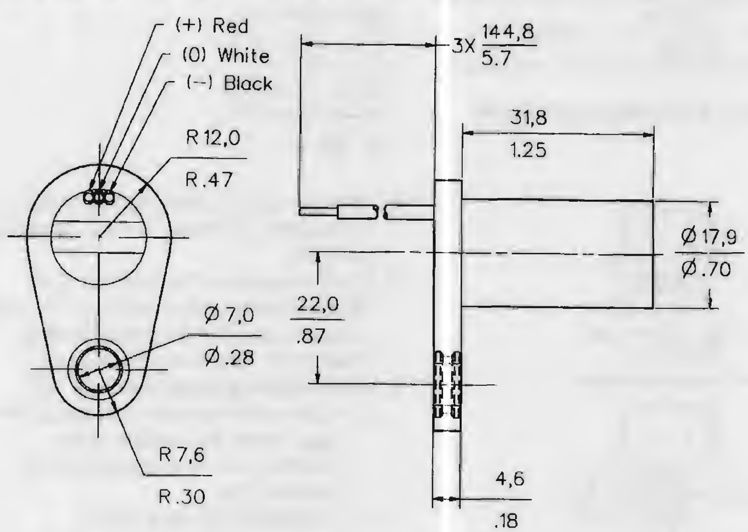
GENERAL INFORMATION
1GT1 Series Gear Tooth Sensors use a magnetically biased Hall effect integrated circuit to accurately sense movement of ferrous metal targets. This specially designed I.C., with discrete capacitor and bias magnet, is sealed in a probe type package for physical protection and cost effective installation.

Units will function from a 4.5 to 24 VDC power supply. Output is digital, current sinking (open collector). Reverse polarity protection is standard. If power is inadvertently wired backwards, the sensor will not be damaged. Built-in protection against pulsed transients to +60V, −40V is also included.

Optimum sensor performance is dependent on the following variables which must be considered in combination:

- Target material, geometry, and speed
- Sensor/target gap
- Ambient temperature
- Magnetic material in close proximity

MOUNTING DIMENSIONS (For reference only)



Solid State Sensors
Hall Effect Gear Tooth Sensors

SENSOR SPECIFICATIONS

All values were measured using 1 K pull-up resistor.

Electrical Characteristics	Supply Voltage	4.5 to 24 VDC
	Supply Current	10 mA typ., 20 mA max.
	Output Voltage (output low)	0.4 V max
	Output Current (output high)	10 µA max. leakage into sensor
	Switching Time Rise (10 to 90%)	15 µsec. max.
	Fall (90 to 10%)	1.0 µsec. max.
Absolute Maximum Ratings*	Supply Voltage (Vs)	±30 VDC continuous
	Voltage Externally Applied To Output (output high)	−0.5 to +30 V
	Output Current	40 mA sinking
	Temperature Range Storage	−40 to 150° (−40 to 302°F)
	Operating	−40 to 150° C (−40 to 302°F)
Switching Characteristics**	Operate Point	3.7±1.25° (3,28±1,13 mm)
	Release Point	4.7±2.50° (4,16±2,21 mm)
	Differential Travel	8.4±3.70° (7,45±3,34 mm)

* As with all solid state components, sensor performance can be expected to deteriorate as rating limits are approached; however, sensors will not be damaged unless the limits are exceeded.
** See Reference Target table.

TARGET GUIDELINES

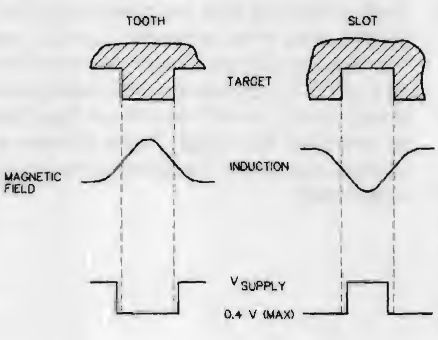
The Target Guidelines table provides basic parameters when an application is not restricted to a specific target.

Any target wheel that exceeds the following minimum specifications can be sensed over the entire temperature range of −40° to 150°C with any sensing gap up to .080 in. (2,0 mm). This data is based on a 4 in. (102 mm) diameter wheel, **rotating 10 to 3600 RPM.**

Reference Target Dimensions

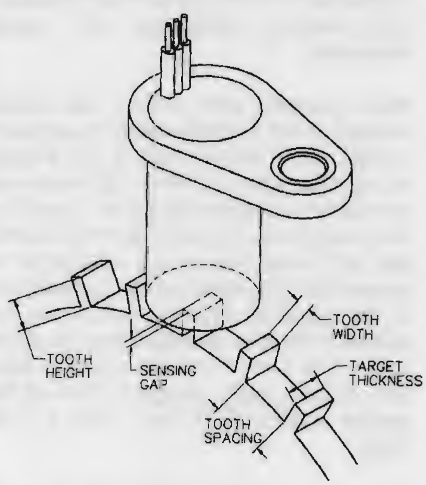
Tooth Height:	.200 in. (5,06 mm) min.
Tooth Width:	.100 in. (2,54 mm) min.
Tooth Spacing:	.400 in. (10,16 mm) min.
Target Thickness:	.250 in. (6,35 mm)

Sensor Output (with pull-up resistor added to output circuit)



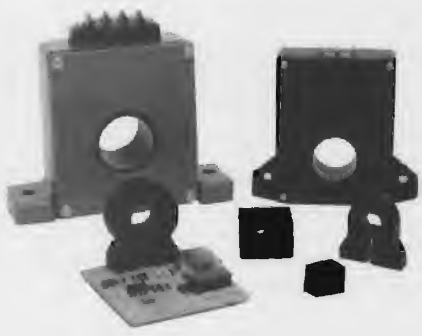
REFERENCE TARGET/CONDITIONS

Characteristics will vary due to target size, geometry, location, and material. Sensor specifications were derived using a cold-rolled steel reference target. See table, right, for reference target configuration and evaluation conditions.



Target	
Diameter:	4 in. (101,6 mm)
Tooth Width:	.350 in. (8,89 mm)
Thickness:	.250 in. (6,35 mm)

Test Conditions	
Air Gap:	.040 to .080 in. (1,02 to 2,03 mm)
V Supply:	4.5 to 24 V
RPM:	10 min., 3600 max.



FEATURES

- Digital or linear output
- AC or DC current sensing
- Through-hole design
- Fast response time
- Output voltage isolation from input
- Minimum energy dissipation
- Maximum current limited only by conductor size
- Adjustable performance and built-in temperature compensation assures reliable operation
- Accurate, low cost sensing
- Operating temperature range −25 to 85°C

APPLICATION

- Variable speed motor controls
- Automotive diagnostics (battery drain detector)
- Ground fault detectors
- Motor overload protection
- Current monitoring of electric welders
- Energy management systems
- Protection of power semiconductors
- Control system diagnostics
- Burnt-out light bulb detection

OPERATION

MICRO SWITCH CS series solid state current sensors monitor either alternating (AC) or direct (DC) current. This series includes a wide assortment of devices ranging from digital output current detectors capable of sensing a few hundred milliamps to linear sensors capable of monitoring over one thousand amps. The entire family of CS current sensors provides a means of accurate low-cost current sensing.

Current sensors monitor current flow. Digital sensors produce a digital output signal. Linear sensors produce an analog output signal. When these signals have reached a predetermined level, the control system logic is instructed to perform a function. The digital signal with its logic level output may sound an alarm, start a motor, open a valve, or shut down a pump. The linear signal duplicates the waveform of the current being sensed and is ideal for use as a feedback element to control a motor or regulate the amount of work being done by a machine.

Some CS current sensors utilize a through-hole design. This feature insures that there will not be any DC insertion loss in the conductor. In addition, the through-hole design simplifies installation by eliminating the need for direct connection, which minimizes energy dissipation, and provides output isolation at no extra cost. MICRO SWITCH CS through-hole current sensors cannot be damaged by overcurrent.

Current sensing is accomplished by measuring the magnetic field surrounding a current-carrying conductor. The conductor is passed through the flux collector which concentrates the magnetic field at the sensing element. The magnetic field is directly proportional to the current passing through the conductor. Thus, there is a direct relationship between the output voltage of the current sensor and the level of input current. The waveform of this output voltage will track the waveform of the measured current. The through-hole design electrically isolates the sensor and insures that it will not be damaged by overcurrent or high voltage transients.

LINEAR CURRENT SENSORS

MICRO SWITCH CSL series linear current sensors incorporate our 91SS12-2 and SS94A1 linear output Hall effect transducer (LOHET™). The sensing element is assembled in a printed circuit board mountable housing. This housing is available in four configurations (as shown in mounting dimension Figures 1, 1a, 2, and 2a on page 59). Normal mounting is with 0.375 inch long 4-40 screw and square nut (not provided) inserted in the housing. The combination of the sensor, flux collector, and housing comprises the holder assembly.

When sensing zero current the output voltage of the current sensor is approximately equal to one half of the supply voltage (Voffset – 0.5 Vcc). CS series linear current sensors will sense current in both directions. Current flow in one direction will cause the output voltage to increase from its offset value. Current flow in the opposite direction will cause the output voltage to decrease from its offset value. The output voltage range is from 25% of the supply voltage to 75% of the supply voltage (0.25 Vcc < Vo < 0.75 Vcc).

While sensing either AC or DC current, the linear output voltage will track the waveform of the sensed current.

The output of these devices can be adjusted by varying the supply voltage, varying the gap cut in the flux collector, or increasing the number of turns of the conductor passing through the center of the flux collector. Devices on page 56 are ratiometric.

ADJUSTABLE LINEAR CURRENT SENSORS

MICRO SWITCH offers two families of linear current sensors with adjustable offset voltage and sensitivity. Both families utilize the previously described linear current sensors mounted to a small printed circuit board containing additional circuitry. The adjustable feature enables the user to define the exact range of operation. The offset voltage and sensitivity are controlled by two trimpots soldered to the printed circuit board. These sensors are ratiometric.

DIGITAL CURRENT SENSORS

Each MICRO SWITCH CSD series digital current sensor provides a logic level output that changes from approximately Vcc to 0.4 volts when the sensed current exceeds the operate point. Each digital sensor will operate on AC or DC current, but the output will turn off at every zero crossing when sensing AC current.

Note: Operate and release currents are specified in Amps-Peak. When monitoring AC current using a digital sensor, peak values should be used. Multiply the RMS values by 1.414 to obtain the peak value.

INDUSTRIAL OUTPUT CURRENT SENSORS

Current sensors with industrial outputs easily interface with programmable controllers and other industrial control and monitoring devices. They have 4 to 20 mA or 1 to 5 VDC outputs and are packaged in a low-cost open PC board configuration or enclosed housings. These devices include a regulator. Therefore, they are not ratiometric.

CATALOG NUMBER SYSTEM

PLEASE NOTE: This matrix is intended **only** to aid you in identifying sensor catalog listings. It is not all-inclusive, and **must not be used** to form new listings.

Example: CSLA1CD

CS Current Sensors
Linear L
Digital D

A1 Holder - 9SS
A2 Holder - SS9
B1 9SS DC-DC Ratiometric Unregulated
B2 9SS AC-DC Ratiometric Unregulated
B3 9SS AC-AC Ratiometric Unregulated
B4 ALC DC-DC Ratiometric Unregulated
B5 ALC AC-DC Ratiometric Unregulated
B6 ALC AC-AC Ratiometric Unregulated
C2 9SS AC-DC 1-5 Unregulated
E1 9SS DC-DC 1-5 V Regulated
E2 9SS AC-DC 1-5 V Regulated
E3 9SS AC-AC 1-5 V Regulated
E4 ALC DC-DC 1-5 V Regulated
E5 ALC AC-DC 1-5 V Regulated
E6 ALC AC-AC 1-5 V Regulated
F1 9SS DC-DC 4-20 mA Regulated
F2 9SS AC-DC 4-20 mA Regulated
F3 9SS AC-AC 4-20 mA Regulated
F4 ALC DC-DC 4-20 mA Regulated
F5 ALC AC-DC 4-20 mA Regulated
F6 ALC AC-AC 4-20 mA Regulated

A PCB Small Holder
B PCB Medium Holder
C Small Holder
D Medium Holder
E Large Holder
F PCB Large Holder
G Small Sidemount
H Plastic Housing Small Opening
J Plastic Housing Large Opening
K Metal Housing
L PCB Small Sidemount

If 9SS

A	14 Amps
B	16
C	33
D	57
E	75
F	100
G	120
H	150
J	225
K	325
L	625

If SS9ALC

	DC-DC	Other
C		24
D	57	72
E		92
F	114	125
G	148	150
H	245	235
J	250	310
K		400
L	490	550
M	604	765
N		950
P	1208	
Q		1500

HOW TO INTERPRET CURRENT SENSOR SPECIFICATIONS

The following definitions will help the user understand the characteristics of the MICRO SWITCH current sensor line.

Adjustable Operating Range — The adjustable linear current sensors give the user the option of changing the sensitivity according to the maximum sensed current of the application. The on-board sensitivity adjustment allows the user to alter the amplification of the Hall effect sensor, thereby adjusting the amount of sensed current needed to achieve maximum output voltage.

Example	Vcc – 12V
Voffset	–Vcc/2 – 6V
Vo maximum	–(75%)Vcc – 9V
Vspan available	–3V

Assume a current maximum of 45 amps is determined. The user would then apply 45 amps through the toroid and adjust the sensitivity where indicated until a 9 volt output is achieved. The sensitivity is then determined as (3V)/(45A) – 67mV/A. This design allows for maximum sensor flexibility.

For best results, choose a sensor to operate toward its maximum operate range. Increased amplification occurs when the sensor is adjusted toward its minimum operate range. Any circuit noise is also amplified.

Offset Shift — The offset shift refers to the effect of temperature on the offset voltage. It is defined as a percentage of reading per degree Celsius. Example: Offset voltage is 6.0V at 25°C. The offset shift is ±0.05%/°C. Therefore, the offset voltage at 35°C is 6.0V ± (0.05%/°C) (6.0V) (10°C) – 6.0V ± 0.03V. The offset shift due to temperature increases as the device is operated toward the temperature extremes.

Offset Voltage — The offset voltage is the voltage output when no current is flowing through the current carrying conductor. This is also known as the null voltage.

Operate Current — The operate current is the level of current required to cause a change in logic state from the state at no current flow. For example, the logic output is high at no current flow. When the current level is increased to the operate point, the logic output goes low.

Ratiometric — Characteristics vary in proportion to supply voltage.

Release Current — The release current is the level of current required to cause a change in logic state as the current flow decreases from the operate point.

Response Time (linear) — Measured from the time the input current reaches 90% of its full scale value to the time when the sensor output reaches 90% of final value. This assumes rise time of 1 microsecond or less on input.

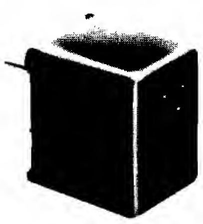
Response Time (digital) — The length of time it takes the output to switch to within ten percent of the supply voltage from the negative supply after the rated operate point is reached on the input. Measured time will vary proportionally with the overdrive current.

Sensed Current (Amps Peak) — The SS94A1 and 91SS12-2 linear output Hall effect sensors have a maximum sensed range. The toroid (flux collector) in each holder assembly has a gap in which the sensor is placed. By varying the width of the gap (lg), the level of current that produces the amount of gauss necessary to saturate the sensor is varied. In other words, the maximum/minimum output of the Hall element will always be obtained at rated gauss excitation. The current level needed to achieve that maximum/minimum output depends on the width of the gap in the flux collector. Max sensed current is also affected by number of times sensed current wire is looped thru sensor hole. If max sensed current is 100 amps and current wire is looped thru hole twice, max sensed current drops to 50 amps. Looped 4 times it drops to 25 amps, 5 times to 20 amps.

Sensitivity - The change in sensor output to 1 amp change in input. Units are in units/NI where N is number of times sensed current wire is looped thru sensor hole. For example, if sensed current wire is looped thru hole twice then sensitivity doubles; looped thru 3 times, sensitivity triples, etc.

Temperature Range — The –25° to +85°C specified is the operating temperature range that the current sensor has been rated. The performance specifications are not considered to be valid outside the specified temperature range.

Solid State Sensors
Series-Connect Digital Current Sensors



FEATURES
- Digital logic level output
- Miniature size
- Encapsulated for physical protection
- Interchangeability
- Printed circuit board mountable
- Transient protection provided on I.C.
- Output voltage isolation from input
- 40 mA current sinking output

TYPICAL APPLICATIONS
- Motor overload protection
- Operations verification
- Power loss detection
- Monitoring
- Burned-out light bulb detection

CS DIGITAL SENSORS

Series-connect current sensors produce a digital logic level output. When the current being sensed reaches a predetermined level, the output changes state.

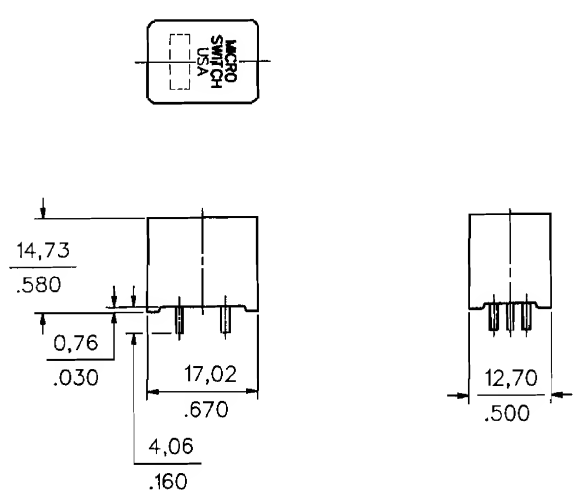
Operating Principle: The sensor, wired in series with the current being sensed, detects the magnetic field surrounding a current-carrying conductor. This current path is passed through a flux collector inside the package, and the magnetic field is concentrated at the internal digital Hall effect sensing element. The magnetic field is proportional to the current passing through the conductor. Thus, there is a relationship between the output state of the current sensor and the level of current. Housing material: PET polyester.

SERIES-CONNECT DIGITAL CURRENT SENSORS ORDER GUIDE, SINKING OUTPUT

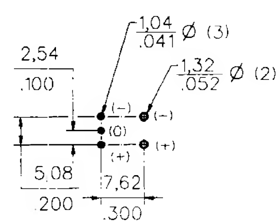
Catalog Listing	Operate Current @ 25°C (Amps)	Release Current @ 25°C (Amps)	Max. Continuous Current (Amps)	Resistance (m Ohm)	Inductance (µH)	Supply Volt. (Volts DC)	Output Volt. (Volts)	Output Current (mA) Sinking	Response Time (µ Sec.)
CSDD1ED	3.5	2.6	10	8	7	4.5 to 24	0.4	40 mA	60
CSDD1EC	5.0	3.8	20	5	4	4.5 to 24	0.4	40 mA	60
CSDD1EE	6.5	4.9	20	4	4	4.5 to 24	0.4	40 mA	60
CSDD1EF	9.0	6.8	20	3	3	4.5 to 24	0.4	40 mA	60
CSDD1EG	10.0	7.6	20	3	3	4.5 to 24	0.4	40 mA	60
CSDD1EH	15.0	11.4	20	2	3	4.5 to 24	0.4	40 mA	60

MOUNTING DIMENSIONS
(For reference only)

Key:
0,00=mm
0.00=in.



SUGGESTED HOLE CENTERS



View from component side of printed circuit board.

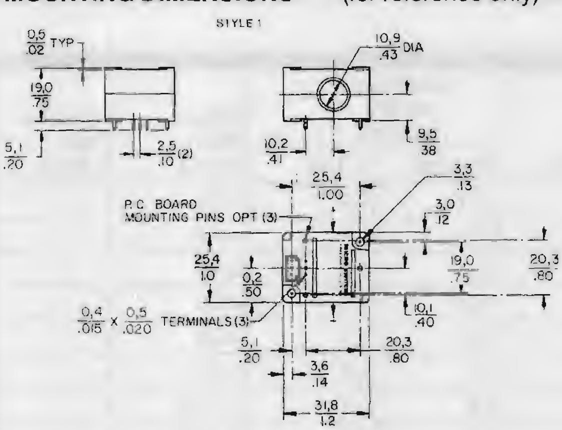
FEATURES
- Digital output
- AC or DC current sensing
- Through-hole design
- Output voltage isolation from input
- Minimum energy dissipation
- Maximum current limited only by conductor size
- Accurate, low cost sensing
- Operating temperature range −25 to 85°C

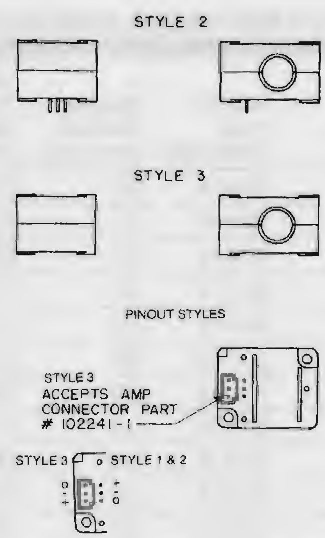
Digital Current Sensors
Each MICRO SWITCH CS series digital current sensor provides a logic level output that changes from approximately Vcc to 0.4 volts when the sensed current exceeds the operate point. Each digital sensor will operate on AC or DC current, but the output will turn off at every zero crossing when sensing AC current. Housing material: PET polyester.

DIGITAL CURRENT DETECTORS ORDER GUIDE, SINKING OUTPUT

Catalog Listings	Pinout Style	Operate Current @ 25°C (Amp-Turns)			Operate Current −25°C to +85°C (Amp-Turns)	Release Current −25°C to +85°C (Amp-Turns Min.)	Supply Volt. (Volts DC)	Output Volt. (Volts)	Output Current (mA) Sinking	Response Time (μ Sec.)
		Min.	Nom.	Max.						
CSDA1BA	2	0.32	0.50	0.88	.25 to 1.0	0.08	6 to 16	0.4	20mA	100
CSDA1BC	2	2.2	3.5	6.5	1.7 to 7.5	0.60	6 to 16	0.4	20mA	100
CSDC1BA	2	0.32	0.50	0.88	.25 to 1.0	0.08	5 ± 0.2	0.4	20mA	100
CSDC1BC	2	2.2	3.5	6.5	1.7 to 7.5	0.60	5 ± 0.2	0.4	20mA	100
CSDA1AA	1	0.32	0.50	0.88	.25 to 1.0	0.08	6 to 16	0.4	20mA	100
CSDA1AC	1	2.2	3.5	6.5	1.7 to 7.5	0.60	6 to 16	0.4	20mA	100
CSDC1AA	1	0.32	0.50	0.88	.25 to 1.0	0.08	5 ± 0.2	0.4	20mA	100
CSDC1AC	1	2.2	3.5	6.5	1.7 to 7.5	0.60	5 ± 0.2	0.4	20mA	100
CSDC1DA	3	0.32	0.50	0.88	.25 to 1.0	0.08	5 ± 0.2	0.4	20mA	100
CSDA1DA	3	0.32	0.50	0.88	.25 to 1.0	0.08	6 to 16	0.4	20mA	100
CSDC1DC	3	2.2	3.5	6.5	1.7 to 7.5	0.60	5 ± 0.2	0.4	20mA	100
CSDA1DC	3	2.2	3.5	6.5	1.7 to 7.5	0.60	6 to 16	0.4	20mA	100

MOUNTING DIMENSIONS (for reference only)





Current

FEATURES

- Linear output
- AC or DC current sensing
- Through-hole design
- Fast response time
- Output voltage isolation from input
- Minimum energy dissipation
- Maximum current limited only by conductor size
- Adjustable performance and built-in temperature compensation assures reliable operation
- Accurate, low cost sensing
- Operating temperature range −25 to 85°C
- Housing: PET polyester

LINEAR CURRENT SENSORS

MICRO SWITCH CS series linear current sensors incorporate our 91SS12-2 and SS94A1 linear output Hall effect transducer (LOHET™). The sensing element is assembled in a printed circuit board mountable housing. This housing is available in four configuration as shown in mounting dimension figures 1, 1a, 2 and 2a. Normal mounting is with 0.375 inch long 4-40 screw and square nut (not provided) inserted in the housing or a 6-20 self-tapping screw. The combination of the sensor, flux collector, and housing comprises the holder assembly. These sensors are ratiometric.

@ 10-A 450μV.

ORDER GUIDE — BOTTOM MOUNT WITH 9SS SENSOR, SOURCE OUTPUT

Catalog Listing	Mtg. Dim. Fig.	Supply Volt. (Volts DC)	Supply Current (mA Max.)	Sensed Current (Amps Peak)	Offset Volt. (Volts±10%)	Sensitivity mV•N* At 12 VDC Nominal	Sensitivity mV•N* At 12 VDC ± TOL	Offset Shift (%/°C)	Response Time (μ Sec.)
CSLA1CD	1	8 to 16	19	57	Vcc/2	49.6	5.8	±.05	3
CSLA1CE	1	8 to 16	19	75	Vcc/2	39.4	4.4	±.05	3
CSLA1DE	2	8 to 16	19	75	Vcc/2	39.1	4.8	±.05	3
CSLA1CF	1	8 to 16	19	100	Vcc/2	29.7	2.7	±.05	3
CSLA1DG	2	8 to 16	19	120	Vcc/2	24.6	2.1	±.05	3
CSLA1CH	1	8 to 16	19	150	Vcc/2	19.6	1.8	±.05	3
CSLA1DJ	2	8 to 16	19	225	Vcc/2	13.2	1.2	±.05	3
CSLA1EJ	1a	8 to 16	19	225	Vcc/2	13.2	1.5	±.05	3
CSLA1DK	2	8 to 16	19	325	Vcc/2	9.1	1.7	±.05	3
CSLA1EK	1a	8 to 16	19	325	Vcc/2	9.4	1.3	±.05	3
CSLA1EL	1a	8 to 16	19	625	Vcc/2	5.6	1.3	±.05	3

BOTTOM MOUNT WITH SS9 SENSOR, SINK/SOURCE OUTPUT

Catalog Listing	Mtg. Dim. Fig.	Supply Volt. (Volts DC)	Supply Current (mA Max.)	Sensed Current (Amps Peak)	Offset Volt. (Volts±2%)	Sensitivity mV•N* At 8 VDC Nominal	Sensitivity mV•N* At 8 VDC ± TOL	Offset Shift (%/°C)	Response Time (μ Sec.)
CSLA2CD	1	6 to 12	20	72	Vcc/2	32.7	3.0	±.02	3
CSLA2CE	1	6 to 12	20	92	Vcc/2	26.1	2.1	±.02	3
CSLA2DE	2	6 to 12	20	92	Vcc/2	25.6	2.2	±.02	3
CSLA2CF	1	6 to 12	20	125	Vcc/2	19.6	1.3	±.02	3
CSLA2DG	2	6 to 12	20	150	Vcc/2	16.2	1.1	±.02	3
CSLA2DJ	2	6 to 12	20	225	Vcc/2	8.7	0.6	±.020	3
CSLA2DH	2	6 to 12	20	235	Vcc/2	9.8	1.1	±.0125	3
CSLA2EJ	1a	6 to 12	20	310	Vcc/2	7.6	0.7	±.0125	3
CSLA2DK	2	6 to 12	20	400	Vcc/2	5.8	0.5	±.0125	3
CSLA2EL	1a	6 to 12	20	550	Vcc/2	4.3	0.4	±.0125	3
CSLA2EM	1a	6 to 12	20	765	Vcc/2	3.1	0.3	±.007	3
CSLA2EN	1a	6 to 12	20	950	Vcc/2	2.3	0.2	±.007	3

NOTE: When monitoring purely AC current with zero DC component, a capacitor can be inserted in series with the output of the current sensor. The capacitor will block out the effect of the temperature variation of the offset voltage which increases the accuracy of the device.

* N = number of turns

SIDE MOUNT WITH 9SS SENSOR, SOURCE OUTPUT

Catalog Listing	Mtg. Dim. Fig.	Supply Volt. (Volts DC)	Supply Current (mA Max.)	Current (Amps Peak)	Sensed Offset Volt. (Volts±10%)	Sensitivity mV•N* At 12 VDC		Sensitivity	
						Nominal	± TOL	Offset Shift (%/°C)	Response Time (μ Sec.)
CSLA1GD	2a	8 to 16	19	57	Vcc/2	49.6	5.8	±.05	3
CSLA1GE	2a	8 to 16	19	75	Vcc/2	39.4	4.4	±.05	3
CSLA1GF	2a	8 to 16	19	100	Vcc/2	29.7	2.7	±.05	3

SIDE MOUNT WITH SS9 SENSOR, SINK/SOURCE OUTPUT

Catalog Listing	Mtg. Dim. Fig.	Supply Volt. (Volts DC)	Supply Current (mA Max.)	Sensed Current (Amps Peak)	Offset Volt. (Volts±2%)	Sensitivity mV•N* At 8 VDC		Offset Shift (%/°C)	Response Time (μ Sec.)
						Nominal	± TOL		
CSLA2GD	2a	6 to 12	20	72	Vcc/2	32.7	3.0	±.02	8
CSLA2GE	2a	6 to 12	20	92	Vcc/2	26.1	2.1	±.02	8
CSLA2GF	2a	6 to 12	20	125	Vcc/2	19.6	1.3	±.02	8
CSLA2GG	2a	6 to 12	20	150	Vcc/2	12.7	0.6	±.02	8

NOTE: When monitoring purely AC current with zero DC component, a capacitor can be inserted in series with the output of the current sensor. The capacitor will block out the effect of the temperature variation of the offset voltage which increases the accuracy of the device.

*N = number of turns.

MOUNTING DIMENSIONS (for reference only)

Figure 1

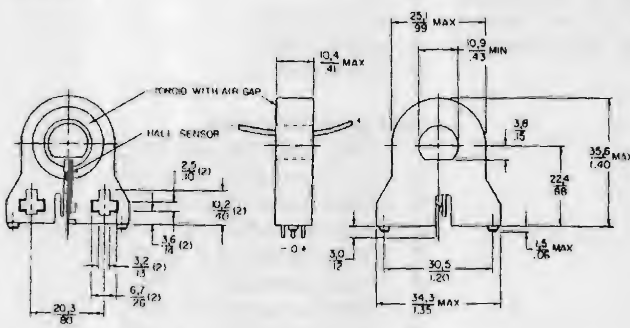


Figure 2

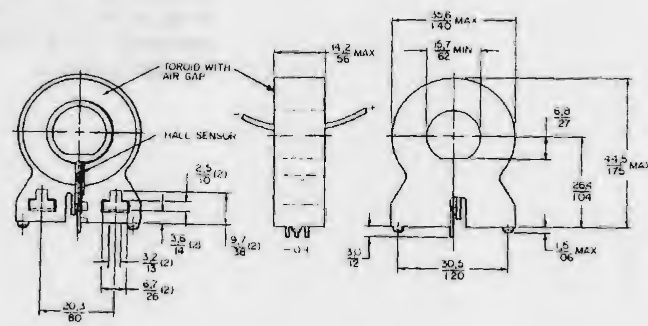


Figure 1a

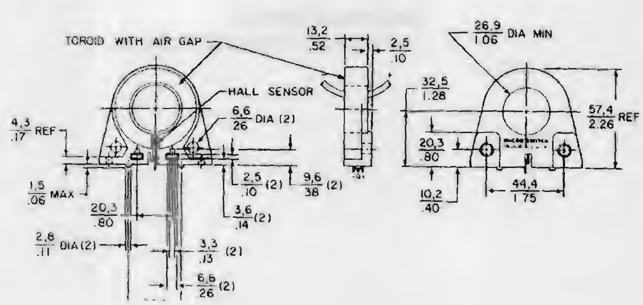
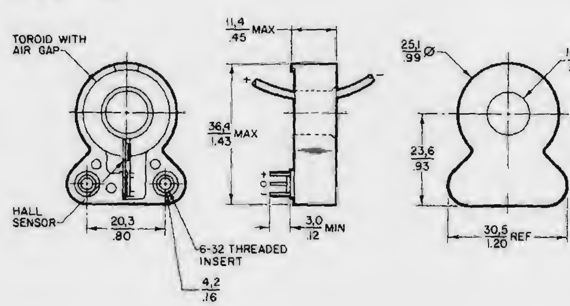
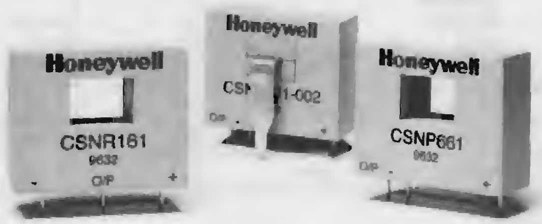


Figure 2a



Current

* Application consideration: The output is clamped at the high end. Clamping voltage may be as low as 9VDC. The output will not exceed the clamping voltage regardless of field strength or supply voltage.



FEATURES

- Current sensing up to 1200 amps
- Measures AC, DC and impulse currents
- Lowest cost/performance ratio
- Rapid response, no overshoot
- High overload capacity
- High level of electrical isolation between primary and secondary circuits
- Small size and weight

CLOSED LOOP SENSORS

Closed loop current sensors measure AC, DC and impulse currents over 0-25, 0-50, 0-100, 0-600 and 0-1200 Amp ranges. The CSN Series is based on the principles of the Hall effect and the null balance or zero magnetic flux method (feedback system). The magnetic flux in the sensor core is constantly controlled at zero. The amount of current required to balance zero flux is the measure of the primary current flowing through the conductor, multiplied by the ratio of the primary to secondary windings. This closed loop current is the output from the device and presents an image of the primary current reduced by the number of secondary turns at any time. This current can be expressed as a voltage by passing it through a resistor.

CATALOG NUMBER SYSTEM

PLEASE NOTE: This matrix is intended **only** to aid you in identifying sensor catalog listings. It is not all-inclusive, and **must not be used** to form new listings.

Example: CSNA111

CSN Closed Loop Current Sensor

Current Range (Peak/RMS nom.)
A ±70 A/50 A rms nom.
B ±100 A/50 A rms nom.
C ±90 A/50 A rms nom.
D ±22 A/15 A rms nom.
E ±36 A/25 A rms nom.
F ±150 A/100 A rms nom.
J ±600 A/300 A rms nom.
K ±1200 A/500 A rms nom.
L ±600 A/300 A rms nom.
M ±1200 A/500 A rms nom.
P ±90 A/50 A rms nom.
R ±200 A/125 A rms nom.
T ±150 A/50 A rms nom.

Supply Voltage
1 ±15 V
2 ±13 V
3 ±5 V
4 ±12 V to 18 V
5 ±15 V to 24 V
6 ±12 V to 15 V

Coil Characteristics
1 1:1000 turns/90 Ω @ 70°C
2 1:2000 turns/160 Ω @ 70°C
3 1:2000 turns/130 Ω @ 70°C
4 1:1000 turns/50 Ω @ 70°C
5 1:1000 turns/110 Ω @ 70°C
6 1:1000 turns/30 Ω @ 70°C
7 1:2000 turns/80 Ω @ 70°C
8 1:2000 turns/25 Ω @ 70°C
9 1:5000 turns/50 Ω @ 85°C

Housing Material
1 Polycarbonate/ABS blend

CSNA, CSNB, CSNE SERIES ORDER GUIDE

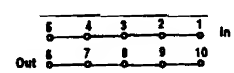
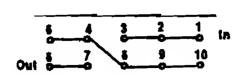
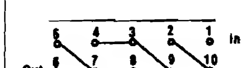
Catalog Listing	Current Range Amps	Supply Voltage VDC ±5%	Coil Characteristics		Meas. Currents Nom.	Meas. Resist (@ I_{nom})
			Turns	Resistance		
CSNA111	±70	±15	1000	90Ω @ 70°C	50 mA for 50 A	40 to 130Ω
CSNB121	±100	±15	2000	160Ω @ 70°C	25 mA for 50 A	40 to 270Ω
CSNB131	±100	±15	2000	130Ω @ 70°C	25 mA for 50 A	40 to 300Ω
CSNE151	±5-36	±15	1000	110Ω @ 70°C	25 mA for 25 A	100 to 320Ω
CSNE381*	±5-36	±5V	1000	66Ω @ 70°C	25 mA for 25 A	0 to 84Ω
CSNH151*	±4-43	±15V	1000	110Ω @ 70°C	25 mA for 25 A	100 to 320Ω

NOTE: Extended temperature range and potting also available.
* Contact the 800 number for more information.

SPECIFICATIONS

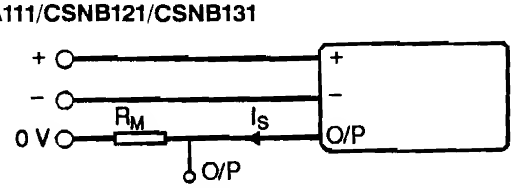
Catalog Listing	CSNA111	CSNB121	CSNB131	CSNE151
Offset Current @ 25°C, mA max.	±0.20	±0.10	±0.10	±0.10
Temperature Drift, 0 to 70°C, mA	±0.35 typ. ±0.60 max.	±0.20 typ. ±0.30 max.	±0.20 typ. ±0.30 max.	±0.17 typ. ±0.60 max.
Linearity	0.1%	0.1%	0.1%	0.2%
Supply Voltage	±15V	±15V	±15V	±15V
Galvanic Isolation @ 50 Hz/1 min.	2.5 kV rms			5 kV rms
Accuracy	±0.5% of I_N (nominal Current) at 25°C			
Response Time	<1 µs			
Bandwidth	DC to 150 kHz			
Temperature	Operating: 0 to 70°C (32 to 150°F) Storage: −25 to 85°C (−13 to 185°F)			
Primary Circuit Connection	Thru-hole	Thru-hole	Thru-hole	Invasive on 10 pins
Secondary Circuit Connection	3 Pins	3 Pins	3 Pins	3 Pins
Current Drain	10 mA (no load current) + output current (secondary current)			
"In-Out" Sense Signal	To obtain positive measuring current on O/P terminal, current must flow in direction of arrow			
Mounting	PCB, 3 pins, hole size 0.95 mm			PCB, 13 pins

PRIMARY PIN CONNECTIONS FOR CSNE151

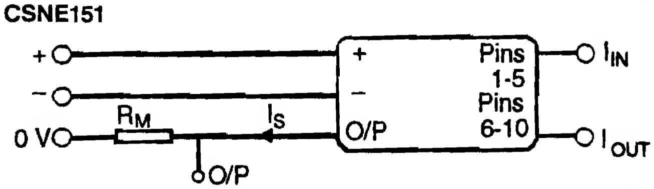
Primary Turns	Primary Current		Output Current (mA)	Primary Resistance (mΩ)	Primary Pin Connections
	Nom. I_{DN} (A)	Max. I_D (A)			
1	24	36	25	0.3	
2	12	18	24	1.1	
3	8	12	24	2.5	
4	6	9	24	4.4	
5	5	7	25	6.3	

WIRING DIAGRAMS

CSNA111/CSNB121/CSNB131



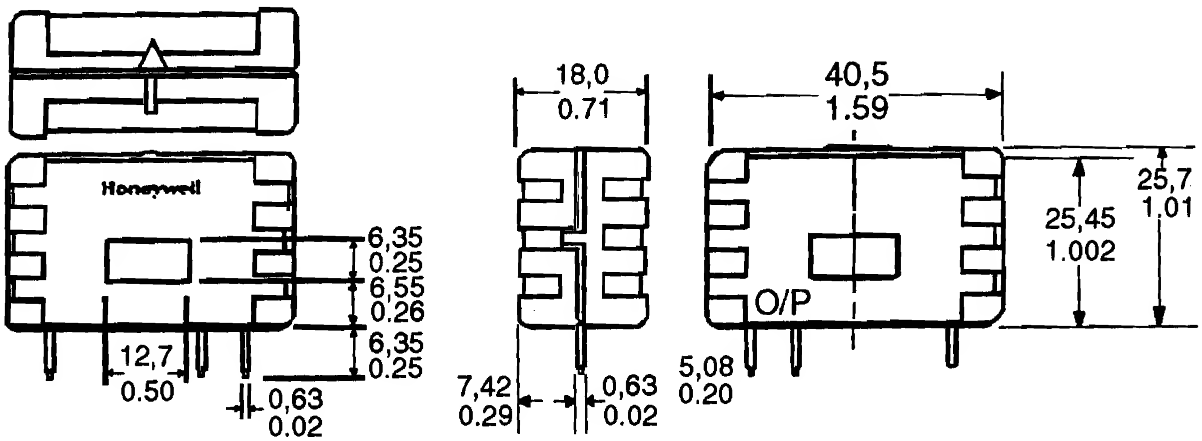
CSNE151



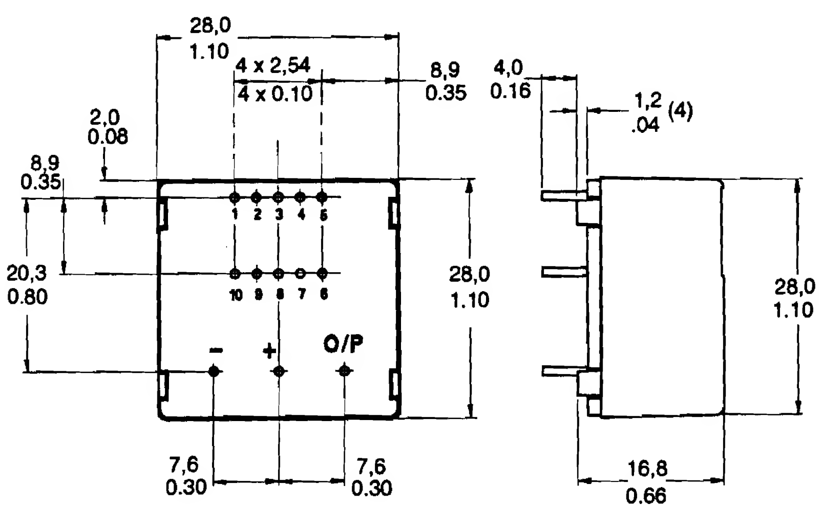
Current

MOUNTING DIMENSIONS (for reference only)

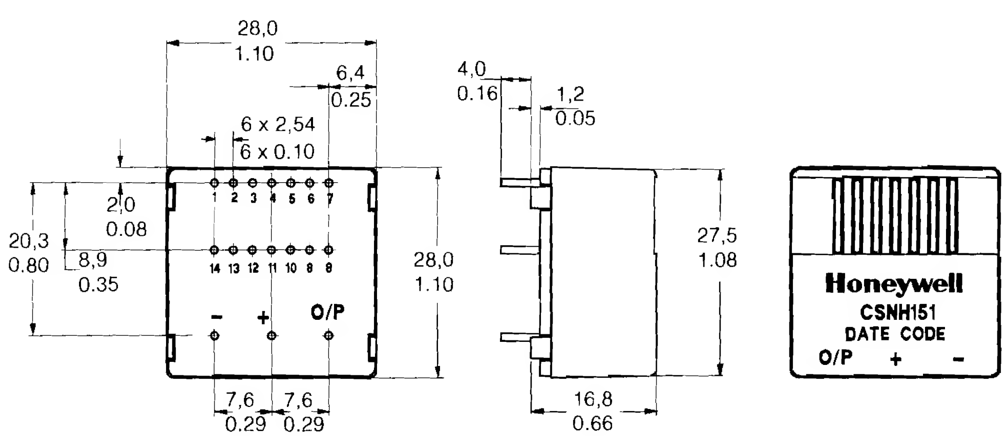
CSNA111, CSNB121, CSNB131



CSNE151/CSNE381



CSNH151



Solid State Sensors
Closed Loop Current Sensors

CSNJ, CSNK SERIES ORDER GUIDE

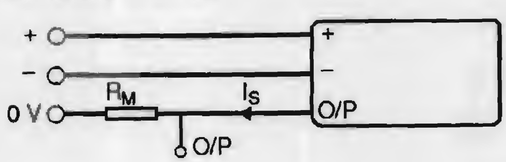
Catalog Listings	Current Range Amps	Supply Voltage VDC ± 5%	Coil Characteristics: Turns	Coil Characteristics: Resistance	Meas. Currents Nom.	Meas. Resist (@ I_{nom})
CSNJ481	±600	±12 to 18	2000	25Ω @ 70°C	150 mA for 300 A	0 to 70Ω
CSNJ481-001*	±600	±12 to 18	2000	25Ω @ 70°C	150 mA for 300 A	0 to 70Ω
CSNJ481-002	±600	±12 to 18	2000	25Ω @ 70°C	150 mA for 300 A	0 to 70Ω
CSNJ481-003*	±600	±12 to 18	2000	25Ω @ 70°C	150 mA for 300 A	0 to 70Ω
CSNK591	±1200	±15 to 24	5000	50Ω @ 70°C	100 mA for 500 A	0 to 130Ω
CSNK591-001*	±1200	±15 to 24	5000	50Ω @ 70°C	100 mA for 500 A	0 to 130Ω
CSNK591-002	±1200	±15 to 24	5000	50Ω @ 70°C	100 mA for 500 A	0 to 130Ω
CSNK591-003*	±1200	±15 to 24	5000	50Ω @ 70°C	100 mA for 500 A	0 to 130Ω

*Fitted with busbar

SPECIFICATIONS

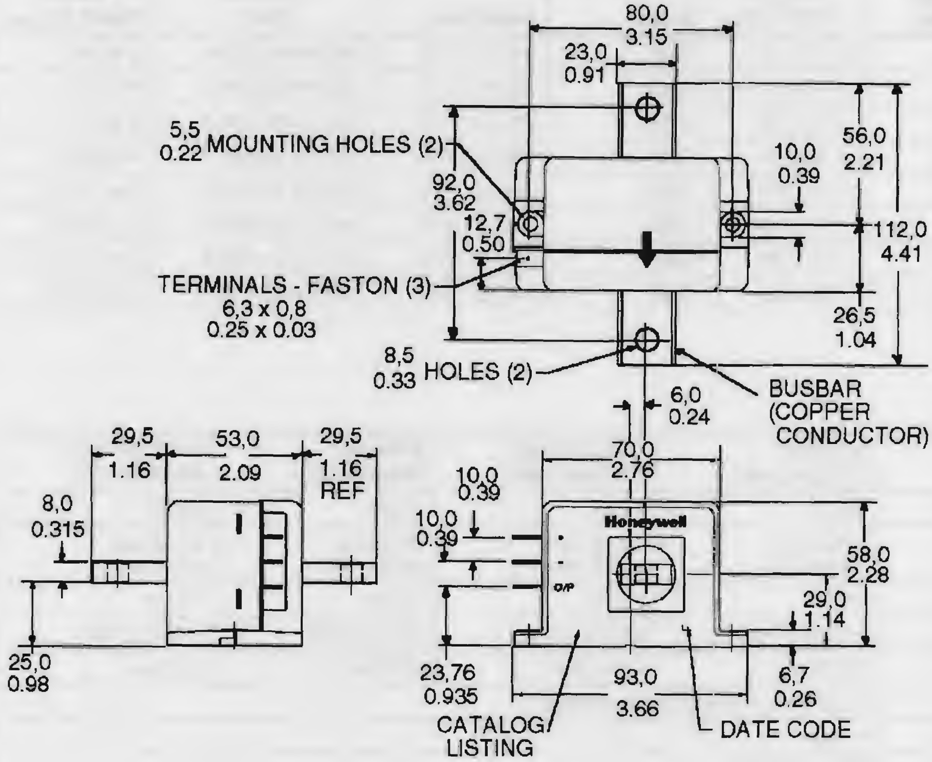
Catalog Listings	CSNJ481 CSNJ481-001	CSNJ481-002 CSNJ481-003	CSNK591 CSNK591-001	CSNK591-002 CSNK591-003
Offset Current @ 25°C, mA max.	±0.30	±0.30	±0.20	±0.20
Temperature Drift, 0 to 70°C, mA	±0.30 typ. ±0.50 max.	±0.30 typ. ±0.50 max.	±0.20 typ. ±0.30 max.	±0.20 typ. ±0.30 max.
Linearity	±0.1%	±0.1%	±0.1%	±0.1%
Supply Voltage	±12 to ±18V	±12 to ±18V	±15 to ±24V	±15 to ±24V
Galvanic Isolation @ 50 Hz/1 min.	7.5 kV rms	7.5 kV rms	6 kV rms	6 kV rms
Accuracy	±0.5% of I_N (nominal Current) at 25°C			
Response Time	<1 μs			
Bandwidth	DC to 150 kHz			
Operating Temperature	−40 to 85°C (−40 to 185°F)	0 to 70°C (32 to 158°F	−40 to 85°C (−40 to 185°F)	0 to 70°C (32 to 158°F)
Storage Temperature	−40 to 90°C (−40 to 194°F)	−25 to 85°C (−13 to 85°F	−40 to 90°C (−40 to 194°F)	−25 to 85°C (−13 to 85°F)
Primary Circuit Connection	Thru-hole or busbar	Thru-hole or busbar	Thru-hole or busbar	Thru-hole or busbar
Secondary Circuit Connection	3 pins	3 pins	3 pins	3 pins
Current Drain	14 mA (no load current) + output current		22 mA (24 V) + output current	
"In-Out" Sense Signal	To obtain positive measuring current on O/P terminal, current must flow in direction of arrow			
Mounting	Faston, 3 pins		Push-on (spade), 3 terminals	

WIRING DIAGRAM

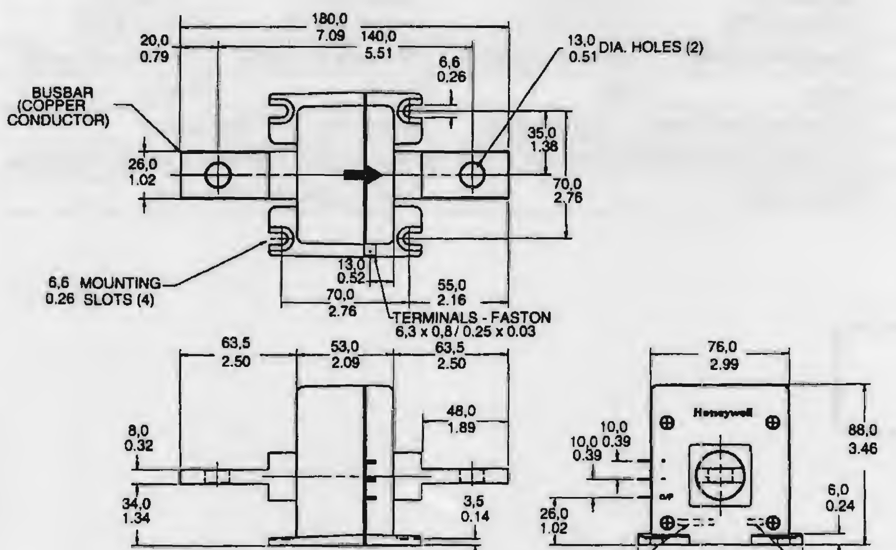


MOUNTING DIMENSIONS (for reference only)

CSNJ481



CSNK591



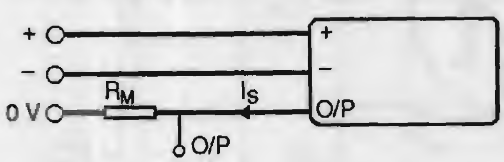
CSNL, CSNM SERIES ORDER GUIDE

Catalog Listings	Peak Current Range Amps	Supply Voltage VDC ± 5%	Coil Characteristics		Meas. Currents Nom.	Meas. Resist (@ I_{nom})
			Turns	Resistance		
CSNL181	±600	±12 to 18	2000	25Ω @ 70°C	150 mA for 300 A	0 to 70Ω
CSNM191	±1000	±12 to 18	5000	50Ω @ 70°C	100 mA for 500 A	0 to 120Ω

SPECIFICATIONS

Catalog Listings	CSNL181	CSNM191
Offset Current @ 25°C, mA max.	±0.30	±0.20
Temperature Drift, 0 to 70°C, mA	±0.30 typ. ±0.50 max.	±0.20 typ. ±0.30 max.
Linearity	±0.1%	±0.1%
Supply Voltage	±12 to ±18V	±12 to ±18V
Galvanic Isolation @ 50 Hz/1 min.	7.5 kV rms	7.5 kV rms
Accuracy	±0.5% of I_N (nominal Current) at 25°C	
Response Time	500 ns	<1 µs
Bandwidth	DC to 150 kHz	
Operating Temperature	−40 to 85°C (−40 to 185°F)	
Storage Temperature	−40 to 90°C (−40 to 194°F)	
Primary Circuit Connection	Thru-hole	Thru-hole
Secondary Circuit Connection	3 pins	3 pins
Current Drain	14 mA (no load current) + output current	
"In-Out" Sense Signal	To obtain positive measuring current on O/P terminal, current must flow in direction of arrow	
Mounting	Faston, 3 pins	

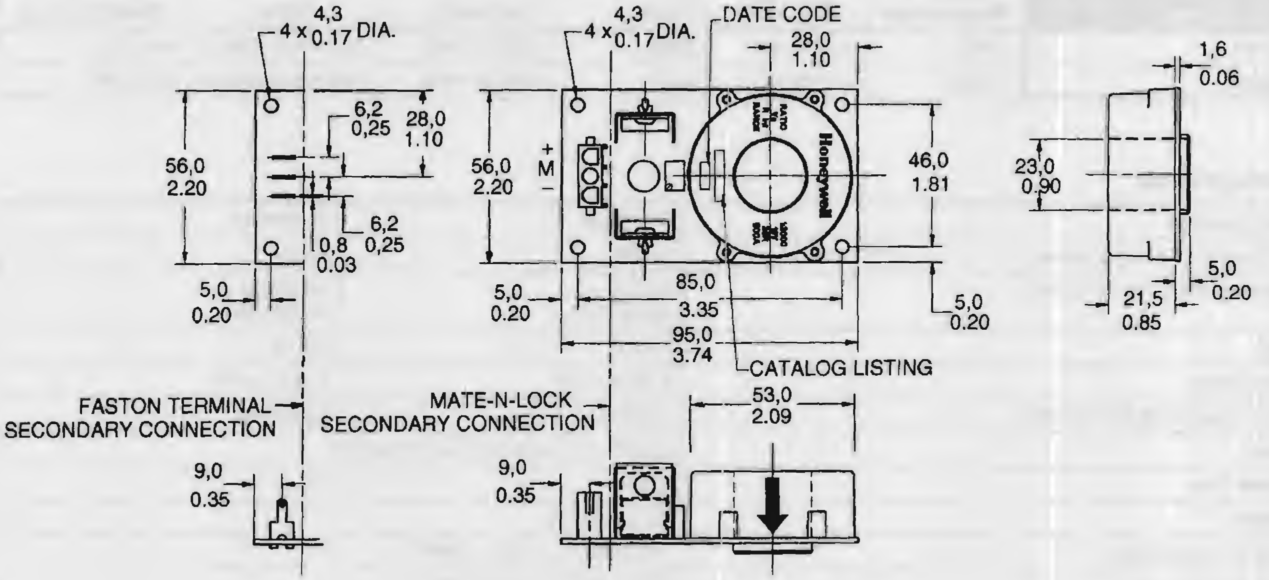
WIRING DIAGRAM



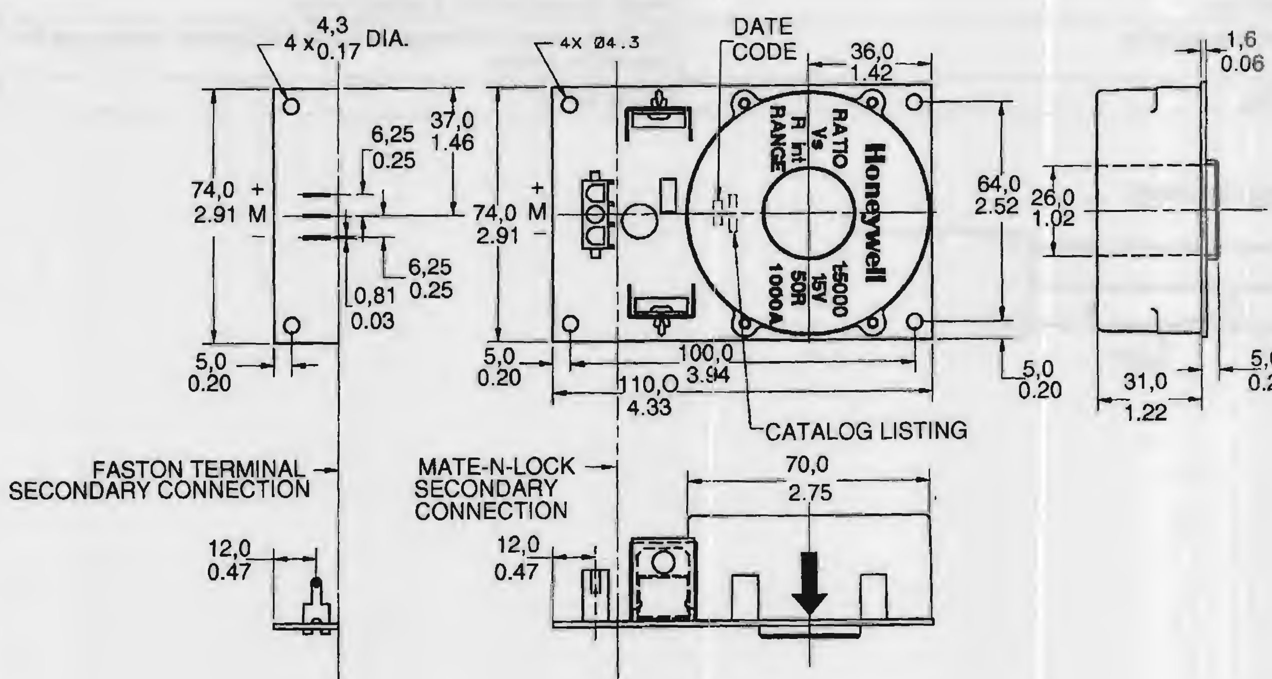
Current

MOUNTING DIMENSIONS (for reference only)

CSNL181



CSNM191



Solid State Sensors
Closed Loop Current Sensors

CSNF, CSNR, CSNP, CSNT SERIES ORDER GUIDE

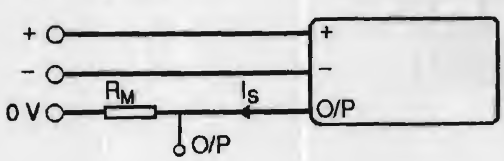
Catalog Listings	Peak Current Range Amps	Supply Voltage VDC ± 5%	Coil Characteristics		Meas. Currents Nom.	Meas. Resist (@ I_{nom})
			Turns	Resistance		
CSNP661	±90	±12 to 15	1000	30Ω @ 70°C	50 mA for 50 A	50 to 100Ω
CSNT651	±150	±12 to 15	2000	100Ω @ 70°C	25 mA for 50 A	40 to 75Ω
CSNF161	±150	±12 to 15	1000	30Ω @ 70°C	100 mA for 100 A	10 to 40Ω
CSNF151	±180	±12 to 15	2000	100Ω @ 70°C	50 mA for 100 A	10 to 75Ω
CSNR161	±200	±12 to 15	1000	30Ω @ 70°C	125 mA for 125 A	30 to 40Ω
CSNR151	±200	±12 to 15	2000	100Ω @ 70°C	62.5 mA for 125 A	10 to 40Ω

NOTE: Busbar options available.

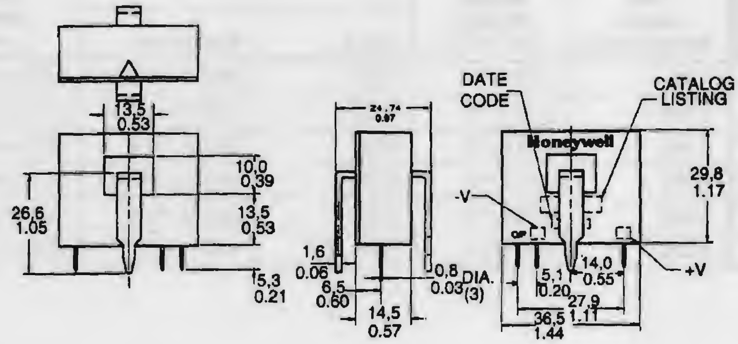
SPECIFICATIONS

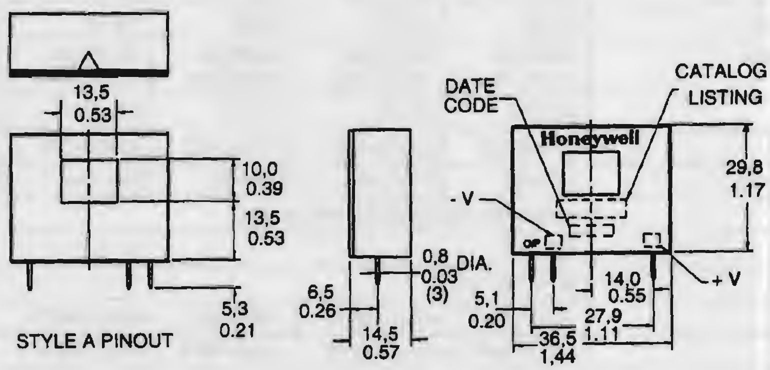
Catalog Listings	CSNP661	CSNT651	CSNF161	CSNF151	CSNR161	CSNR151
Offset Current @ 25°C, mA max.	±0.20	±0.10	±0.20	±0.10	±0.20	±0.10
Temperature Drift, 0 to 70°C, mA	±0.30 typ. ±0.50 max.	±0.15 typ. ±0.25 max.	±0.30 typ. ±0.50 max.	±0.15 typ. ±0.25 max.	±0.30 typ. ±0.60 max.	±0.15 typ. ±0.30 max.
Linearity	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%
Supply Voltage	±12 to 15V	±12 to 15V	±12 to 15V	±12 to 15V	±12 to 15V	±12 to 15V
Galvanic Isolation @ 50 Hz/1 min.	3 kV rms	3 kV rms	3 kV rms	3 kV rms	3 kV rms	3 kV rms
Accuracy	±0.5% of I_N (nominal Current) at 25°C					
Response Time	<500 ns					
Bandwidth	DC to 150 kHz					
Operating Temperature	−40 to 85°C (−40 to 185°F)		−40 to 85°C (−40 to 185°F)			
Storage Temperature	−40 to 90°C (−40 to 194°F)		−40 to 90°C (−40 to 194°F)			
Primary Circuit Connection	Thru-hole					
Secondary Circuit Connection	3 pins					
Current Drain	10 mA (no load current) + output current		14 mA (no load current) + output current			
"In-Out" Sense Signal	To obtain positive measuring current on O/P terminal, current must flow in direction of arrow					
Mounting	3 pins					
Pin Style	A	A	B	B	B	B

WIRING DIAGRAM

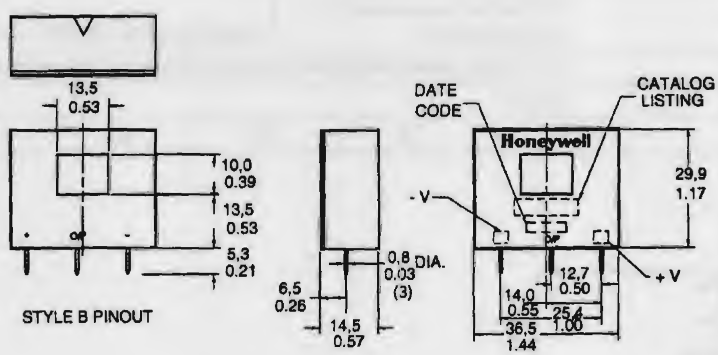


MOUNTING DIMENSIONS (for reference only)





STYLE A PINOUT



STYLE B PINOUT

ADJUSTABLE LINEAR SENSORS DC/DC

This family is designed to provide a DC output voltage while sensing DC current. By adjusting the offset voltage trimpot the user can adjust the offset to one half of the supply voltage. The full scale current output voltage can be adjusted by the use of the sensitivity trimpot. Depending on the direction of current flow, the output voltage wil either increase or decrease from the offset value. These sensors can sense current from 0 to 50 kHz. Ratio metric sink/source output.

NOTE: DC/DC sensors should be used to sense AC current when a DC bias is present.

Due to magnetic properties a residual magnetic field can remain present in the flux collector at zero current. To facilitate resolution of DC current in the lower 1% of the dynamic range, adjust the null offset after a nominal level of current has passed thru the sensor.

DC/DC ORDER GUIDE RATIOMETRIC SINK/SOURCE OUTPUT

Catalog Listings	Mtg. Dim. Fig.	Supply Volt. (Volts DC)	Supply Current (mA Max.)	Max. Sensed Current (Amps-Peak)	Adjustable Operating Range @ Vcc – 12VDC*				Offset Volt. (Volts)	Offset Shift (%/°C)	Response Time (μ Sec.)
					Min. Sens. (mV/NI)	Oper. Range (Amps)	Max. Sens. (mV/NI)	Oper. Range (Amps)			
CSLB1AD	3	10 to 15	30	57	53	0-57	90	0-33	Vcc/2	±.03	8
CSLB1BE	4	10 to 15	30	75	40	0-75	75	0-40	Vcc/2	±.03	8
CSLB1AF	3	10 to 15	30	100	30	0-100	55	0-55	Vcc/2	±.03	8
CSLB1BG	4	10 to 15	30	120	25	0-120	46	0-65	Vcc/2	±.03	8
CSLB1AH	3	10 to 15	30	150	20	0-150	38	0-80	Vcc/2	±.03	8
CSLB1BJ	4	10 to 15	30	225	13	0-225	26	0-115	Vcc/2	±.03	8
CSLB1BK	4	10 to 15	30	325	9	0-325	16	0-185	Vcc/2	±.03	8

* For best results, choose a sensor to operate toward its maximum operate range. Increased amplification occurs when adjusting toward a minimum operate range; noise is also amplified.
Operating temperature range: –25 to +85°C

MOUNTING DIMENSIONS (for reference only)

Figure 3

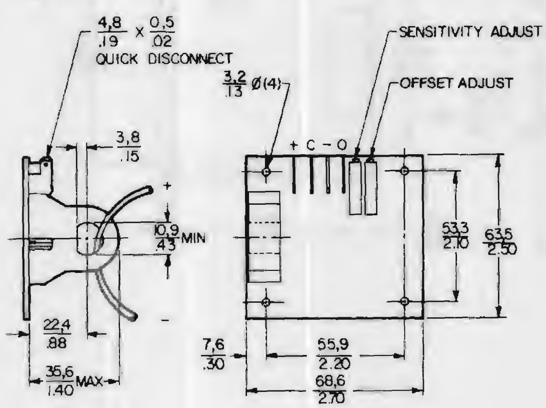
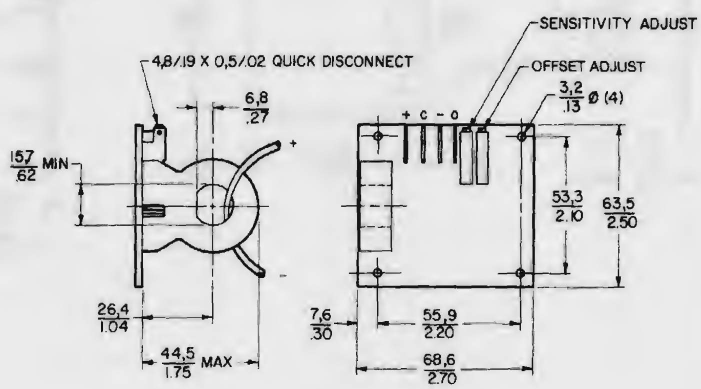


Figure 4



Adjustable Linear Current Sensors

AC/DC

This family is designed to provide a DC output voltage while sensing AC current. The signal conditioning circuitry rectifies and filters the AC waveform into a 1.0 to 5.0 volt DC output signal. The offset voltage trimpot is used to adjust the offset at 1.0 volts. The sensitivity trimpot is used to adjust the maximum output voltage. AC/DC sensors are optimized to sense AC current from 50 Hz to 70 Hz, however, they can sense current from 10 Hz to 15 kHz. Ratiometric sink/source output.

NOTE: The input of the AC/DC sensors is capacitive coupled and should not be used to sense DC current.

AC/DC ORDER GUIDE RATIOMETRIC SINK/SOURCE OUTPUT

Catalog Listings	Mtg. Dim. Fig.	Supply Volt. (Volts DC)	Supply Current (mA Max.)	Max. Sensed Current (Amps-Peak)	Adjustable Operating Range @ Vcc – 12VDC*				Offset Volt. (Volts)	Offset Shift (%/°C)	Response Time (mSec.)
					Min. Sens. (mV/NI)	Oper. Range (Amps)	Max. Sens. (mV/NI)	Oper. Range (Amps)			
CSLB2AB	5	10 to 15	30	16	188	0-16	428	0-7	Vcc/2	±.063	700
CSLB2AC	5	10 to 15	30	33	90	0-33	214	0-14	Vcc/2	±.031	700
CSLB2AD	5	10 to 15	30	57	53	0-57	107	0-28	Vcc/2	±.018	700
CSLC2AD	5	12	30	57	70	0-57	190	0-21	1.0	±.083	700
CSLC2BE	6	12	30	75	53	0-75	154	0-26	1.0	±.083	700
CSLC2AF	5	12	30	100	40	0-100	114	0-35	1.0	±.083	700
CSLC2BG	6	12	30	120	33	0-120	98	0-41	1.0	±.083	700
CSLC2AH	5	12	30	150	27	0-150	80	0-50	1.0	±.083	700
CSLC2BJ	6	12	30	225	18	0-225	53	0-75	1.0	±.083	700
CSLC2BK	6	12	30	325	12	0-325	34	0-118	1.0	±.083	700

* For best results, choose a sensor to operate toward its maximum operate range. Increased amplification occurs when adjusting toward a minimum operate range; noise is also amplified.

The common terminal "C" is used when the sensor is excited by dual supplies. With dual excitation, the offset voltage is 0 volts for the first three AC/DC listings shown above. For the remaining AC/DC sensors, the offset voltage is adjusted to −5.0 volts when using +6 volt supplies.

MOUNTING DIMENSIONS (for reference only)

Figure 5

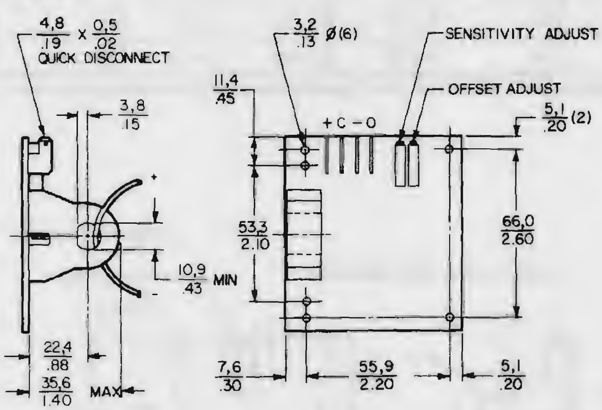
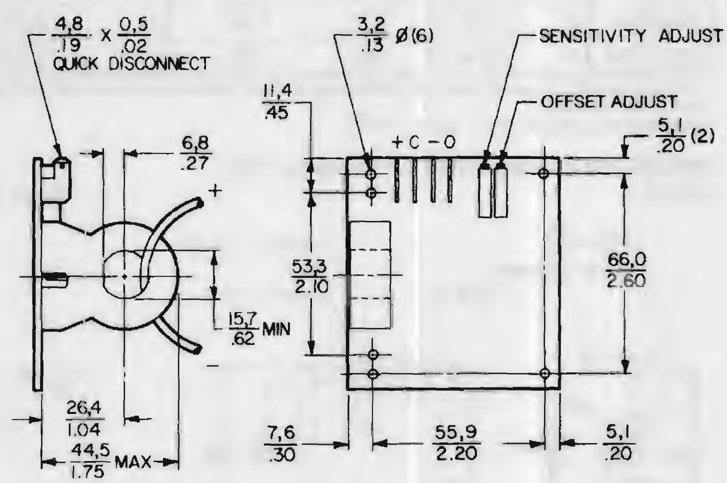


Figure 6



ADJUSTABLE LINEAR SENSORS WITH STANDARD INDUSTRIAL OUTPUTS

The through-hole sensor housing is mounted on a small printed circuit board containing additional circuitry and two trimpots. Offset voltage is controlled by one trimpot, while the other controls sensitivity. By adjusting the trimpots, the user defines the exact range of operation. A regulator is used on each circuit. Output is ratiometric. Terminate 1 to 5 volt outputs with ≥500 ohms. Terminate 4 to 20 mA with ≤250 ohms.

DC/DC sensors provide a DC output voltage/current while sensing DC current. The offset voltage trimpot enables the offset to be either 1 volt or 4 milliamps. The full scale output voltage/current can be adjusted by using the sensitivity trimpot.

AC/DC sensors provide a DC output voltage while sensing AC current. The signal conditioning circuitry rectifies and filters the AC waveform into a 1.0 to 5.0 volt DC or a 4 to 20 mA output signal. The offset trimpot adjusts the offset at a 1.0 volt or 4 mA. The sensitivity trimpot adjusts the maximum output voltage/current. AC/DC sensors can sense AC current from 50 to 400 Hz.

NOTE: The input of AC/DC sensors is capacitive coupled. They should not be used to sense DC current.

NOTE: DC/DC sensors should be used to sense AC current when a DC bias is present.

DC/DC SENSORS WITH 1.0 to 5.0 VOLTS SINK/SOURCE OUTPUT ORDER GUIDE/OPERATING CHARACTERISTICS

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (mV/NI)	Oper. Range (Amps)	Max. Sens. (mV/NI)	Oper. Range (Amps)	Offset Voltage (Volts)	Offset Shift (%/°C)	Response Time (µ Sec. typ.)
CSLE4AD	1	10.5 to 24	30	57	70	57	138	29	1.0	±0.092	8
CSLE4AF	1	10.5 to 24	30	114	35	114	70	57	1.0	±0.092	8
CSLE4BG	2	10.5 to 24	30	148	27	148	54	74	1.0	±0.092	8
CSLE4FH	3	10.5 to 24	30	245	16	245	33	123	1.0	±0.092	8
CSLE4FL	3	10.5 to 24	30	490	8	490	16	245	1.0	±0.063	8

Note: Output current 10mA max. source, 1mA max. sink.

AC/DC SENSORS WITH 1.0 to 5.0 VOLTS SINK/SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (mV/NI)	Oper. Range (Amps)	Max. Sens. (mV/NI)	Oper. Range (Amps)	Offset Voltage (Volts)	Offset Shift (%/°C)	Response Time (mSec. typ.)
CSLE5AC	1	10.5 to 24	30	24	167	24	500	8	1.0	±0.04	150
CSLE5AD	1	10.5 to 24	30	72	56	72	167	24	1.0	±0.04	150
CSLE5BE	2	10.5 to 24	30	92	43	92	129	31	1.0	±0.04	150
CSLE5FG	3	10.5 to 24	30	153	26	153	78	51	1.0	±0.04	150
CSLE5FK	3	10.5 to 24	30	408	10	408	29	136	1.0	±0.04	150
CSLE5FN	3	10.5 to 24	30	950	4	950	12	340	1.0	±0.04	150

Note: Output current 10mA max. source, 1mA max. sink.

DC/DC SENSORS WITH 4.0 to 20.0 MILLIAMPS SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (µA/NI)	Oper. Range (Amps)	Max. Sens. (µA/NI)	Oper. Range (Amps)	Offset Current (mA)	Offset Shift (%/°C)	Response Time (mSec. typ.)
CSLF4AD	1	10.5 to 24	30	57	280	57	552	29	4.0	±0.125	8
CSLF4AF	1	10.5 to 24	30	114	140	114	281	57	4.0	±0.125	8
CSLF4BG	2	10.5 to 24	30	148	108	148	216	74	4.0	±0.125	8
CSLF4FH	3	10.5 to 24	30	245	65	245	130	123	4.0	±0.125	8
CSLF4FL	3	10.5 to 24	30	490	32	490	65	245	4.0	±0.125	8

* Optimum accuracy is obtained when operating the sensor at maximum sensed current.

Current

AC/DC SENSORS WITH 4.0 TO 20.0 MILLIAMPS SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range				Offset Voltage (Volts)	Offset Shift (%/°C)	Response Time (mSec. typ.)
					Min. Sens. (μA/NI)	Oper. Range (Amps)	Max. Sens. (μA/NI)	Oper. Range (Amps)			
CSLF5AC	1	10.5 to 24	30	24	667	24	2000	8	4.0	±0.043	150
CSLF5AD	1	10.5 to 24	30	72	222	72	667	24	4.0	±0.043	150
CSLF5BE	2	10.5 to 24	30	92	174	92	516	31	4.0	±0.043	150
CSLF5FG	3	10.5 to 24	30	153	105	153	314	51	4.0	±0.043	150
CSLF5FK	3	10.5 to 24	30	408	39	408	118	136	4.0	±0.043	150
CSLF5FN	3	10.5 to 24	30	950	17	950	47	340	4.0	±0.043	150

* Optimum accuracy is obtained when operating the sensor at maximum sensed current.

MOUNTING DIMENSIONS

Dimensions shown are for reference only. Key: $\frac{0,0\text{–mm}}{0.00\text{–in.}}$

Fig. 1

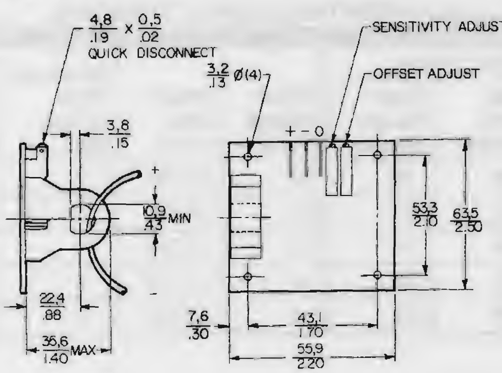


Fig. 2

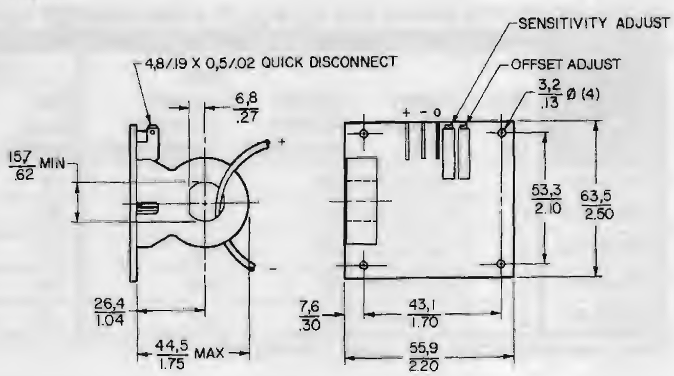
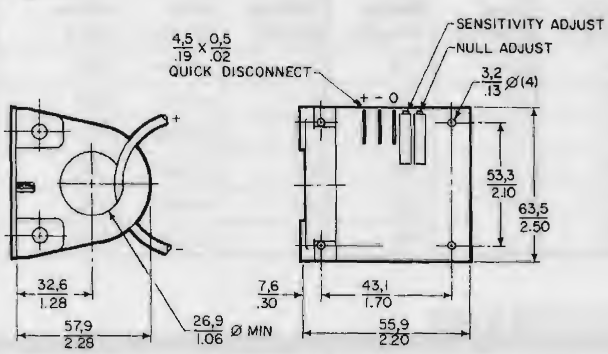
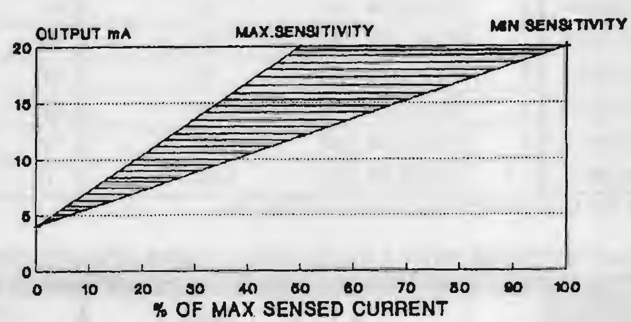


Fig. 3



Adjustable Linear Current Sensor
Range of Adjustment



Industrial Enclosed Linear Current Sensors

TYPICAL APPLICATIONS
- In-line test equipment
- Automotive diagnostics (battery drain detector, alternator monitor)
- Ground fault detectors
- Motor overload protection
- Current monitoring of electric welders
- Energy management systems
- Protection of power semiconductors

FEATURES
- Adjustable operating range
- Industrial standard 1 to 5 VDC or 4 to 20 mA output
- Regulated power supply accepts 0.5 to 24 VDC input
- AC or DC current sensing
- Through-hole design
- Fast response time
- Output voltage isolation from input
- Minimum energy dissipation
- Sensors available with adjustable performance feature
- Built-in temperature compensation promotes reliable operation
- Operating temperature range: −25° to 85°C (−13° to 185°F)
- Accurate, low-cost sensing

DC/DC sensors provide a DC output voltage/current while sensing DC current. The offset voltage trimpot enables the offset to be either 1 volt or 4 milliamps. The full scale output voltage/current can be adjusted by using the sensitivity trimpot.

AC/DC sensors provide a DC output voltage while sensing AC current. The signal conditioning circuitry rectifies and filters the AC waveform into a 1.0 to 5.0 volt DC or a 4 to 20 mA output signal. The offset trimpot adjusts the offset at 1.0 volt or 4 mA. The sensitivity trimpot adjusts the maximum output voltage/current. These sensors can sense AC current from 50 to 1000 Hz. (AC/DC sensors without the adjustable performance feature are factory adjusted @ 60 Hz.)

GENERAL INFORMATION
CS Series solid-state industrial linear current sensors are completely enclosed to provide the circuitry and sensing elements a degree of protection from contaminants and physical damage. They detect variations iin the flow of either alternating (AC) or direct (DC) current. The sensor output easily interfaces with programmable controllers and other industrial control and monitoring devices.

While monitoring current flow up to 1,000 amperes, these sensors produce a linear output signal (1 to 5 volts DC or 4 to 20 milliamps). This signal duplicates the waveform of the DC current being sensed and responds to peak AC current levels. It is ideal for use as a feedback element to control a motor or regulate the amount of work being done by a machine.

NOTE: DC/DC sensors should be used to sense AC current when a DC bias is present.

NOTE: The input of AC/DC sensors is capacitive coupled. They **cannot** be used to sense DC current.

DC/DC SENSORS WITH 1.0 TO 5.0 VOLTS SINK/SOURCE OUTPUT ORDER GUIDE/OPERATING CHARACTERISTICS

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (mV/NI)	Oper. Range (Amps)	Max. Sens. (mV/NI)	Oper. Range (Amps)	Offset Voltage (Volts)	Offset Shift (%/°C)	Response Time (mSec. typ.)
CSLE4HG	4	10.5 to 24	30	147	28	147	54	73	1.0	±0.092	0.008
CSLE4JH	5	10.5 to 24	30	245	17	245	32	122	1.0	±0.092	0.008
CSLE4JM	5	10.5 to 24	30	600	7	600	13	300	1.0	±0.092	0.008
CSLE4KM	6	10.5 to 24	30	600	7	600	—	—	1.0	±0.092	1.000
CSLE4KP	6	10.5 to 24	30	1200	4	1200	—	—	1.0	±0.063	1.000

Note: Output current 10mA max. source, 1mA max. sink.

AC/DC SENSORS WITH 1.0 TO 5.0 VOLTS SINK/SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (mV/NI)	Oper. Range (Amps)	Max. Sens. (mV/NI)	Oper. Range (Amps)	Offset Voltage (Volts)	Offset Shift (%/°C)	Response Time (mSec. typ.)
CSLE5HE	4	10.5 to 24	30	92	44	92	1333	30	1.0	±0.04	150
CSLE5JG	5	10.5 to 24	30	153	27	153	78	51	1.0	±0.04	150
CSLE5JK	5	10.5 to 24	30	408	10	408	294	136	1.0	±0.04	150
CSLE5KQ	6	10.5 to 24	30	1500	3	1500	—	—	1.0	±0.04	150

Note: Output current 10mA max. source, 1mA max. sink.

DC/DC SENSORS WITH 4.0 TO 20.0 MILLIAMPS SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (µA/NI)	Oper. Range (Amps)	Max. Sens. (µA/NI)	Oper. Range (Amps)	Offset Amps (mA)	Offset Shift (%/°C)	Response Time (mSec. typ.)
CSLF4HG	4	10.5 to 24	30	147	109	147	219	73	4.0	±0.125	0.008
CSLF4JH	5	10.5 to 24	30	245	66	245	131	122	4.0	±0.125	0.008
CSLF4KM	6	10.5 to 24	30	600	27	600	—	—	4.0	±0.125	1.000
CSLF4KP	6	10.5 to 24	30	1200	14	1200	—	—	4.0	±0.085	1.000

*Optimum accuracy is obtained when operating the sensor at maximum sensed current.

AC/DC SENSORS WITH 4.0 TO 20.0 MILLIAMPS SOURCE OUTPUT ORDER GUIDE

Catalog Listing	Mtg. Dim. Fig.	Supply Voltage (DC)	Supply Current (mA max.)	Max. Sensed Current* (Amps-Peak)	Adjustable Operating Range: Min. Sens. (µA/NI)	Oper. Range (Amps)	Max. Sens. (µA/NI)	Oper. Range (Amps)	Offset Amps (mA)	Offset Shift (%/°C)	Response Time (mSec. typ.)
CSLF5HD	4	10.5 to 24	30	18	889	18	2666	6	4.0	±0.043	150
CSLF5HE	4	10.5 to 24	30	92	174	92	533	30	4.0	±0.043	150
CSLF5JG	5	10.5 to 24	30	153	105	153	313	51	4.0	±0.043	150
CSLF5JK	5	10.5 to 24	30	408	40	408	117	136	4.0	±0.043	150
CSLF5KQ	6	10.5 to 24	30	1500	11	1500	–	–	4.0	±0.043	150

*Optimum accuracy is obtained when operating the sensor at maximum sensed current.

MOUNTING DIMENSIONS

Dimensions shown are for reference only.

Key: 0,0 = mm / 0.00 = inches

Fig. 4 Plastic Housed

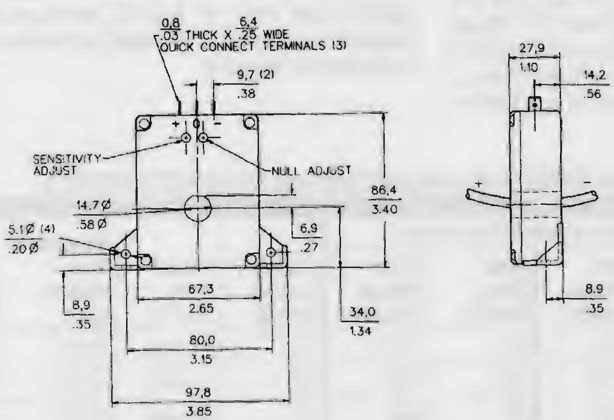


Fig. 5 Plastic Housed

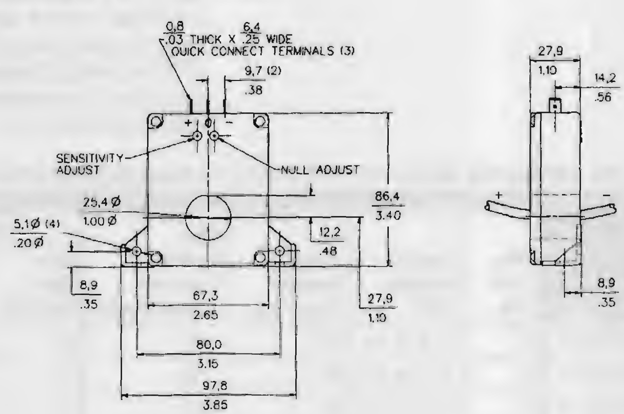
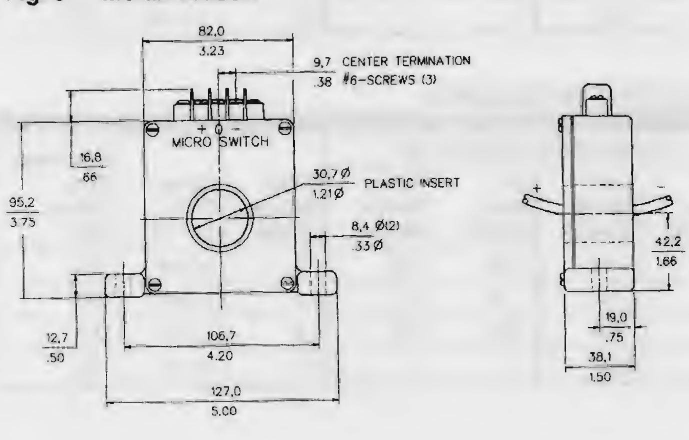
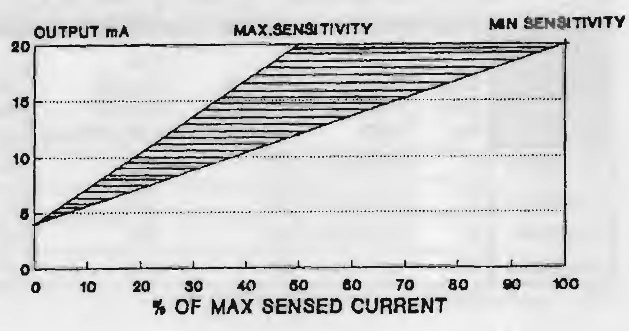


Fig. 6 Metal Housed



Adjustable Linear Current Sensor
Range of Adjustment



Solid State Sensors

Absolute Maximum Ratings

ABSOLUTE MAXIMUM RATINGS — 103SR

		4.5 to 5.5VDC	6 to 24VDC	4.5 to 24VDC
Supply Voltage (Vs)		−1.2 to +10VDC	−1.2 to +24VDC	−1.0 to +25VDC
Voltage Externally Applied to Output (VDC)	Sink/OFF only	+10 max.	+24 max.	+25 max.
	Sink/ON or OFF	−0.5 min.	−0.5 min.	−0.5 min.
	Source	+6.5 max. (ON or OFF)	+6.5 max. (OFF only)	—
	Source/ON only	−0.5 min.	(Vs +4)	—
Output Current (mA)	Sink	20	40	20
	Source	40	20	—
Temperature NOTE: Some SR sensors have wire insulation that can only withstand 85°C. Please contact the 800 number.		−40° to +100°C (−40° to +212°F)	−40° to +100°C (−40° to +212°F)	−40° to 100°C (−40° to +212°F)
Magnetic Flux		No limit. Circuit cannot be damaged by magnetic overdrive.		

ABSOLUTE MAXIMUM RATINGS — SS41/SS11/VX

		4.5 to 24VDC
Supply Voltage (Vs)		−24 to +28VDC
Voltage Externally Applied to Output (VDC)	OFF only	+28 max.
	ON or OFF	−0.5 min.
Output Current (mA)		20
Temperature range, SS41		−55° to +170°C (−67° to +338°F)
Temperature range, SS11		−40° to +150°C (−40° to +302°F)
Temperature range, VX		−40° to +70°C (−40° to +158°F)
Magnetic Flux		No limit. Circuit cannot be damaged by magnetic overdrive.

ABSOLUTE MAXIMUM RATINGS — 2SSP

	4.5 to 5.5VDC	6 to 24VDC
Supply Voltage (Vs)	−1.2 to +7VDC	−1.2 to +24VDC
Voltage Externally Applied to Output	+20VDC max. (OFF only) −0.5VDC min. (ON or OFF)	+24VDC max. (OFF only) −0.5VDC min. (ON or OFF)
Output Current	20mA	20mA
Temperature	−40° to +150°C (−40° to +302°F)	−40° to +150°C (−40° to +302°F)
Magnetic Flux	No limit. Circuit cannot be damaged by magnetic overdrive.	

ABSOLUTE MAXIMUM RATINGS — SS400

	3.8 to 30VDC
Supply Voltage	−0.5 to +30VDC
Voltage Externally Applied to Output	+30VDC max. (OFF condition only) −0.5VDC min. (OFF or ON condition)
Output ON Current	50mA maximum
Temperature range Operating Storage	 −55 to +160°C (−67 to +320°F) −65 to +160°C (−85 to +320°F)
Magnetic Flux	No limit. Circuit cannot be damaged by magnetic overdrive.

NOTICE

Absolute maximum ratings are the extreme limits the device will withstand without damage to the device. However, the electrical and mechanical characteristics are not guaranteed as the maximum limits (above recommended operating conditions) are approached, nor will the device necessarily operate at absolute maximum ratings.

Solid State Sensors

Absolute Maximum Ratings

			4.5 to 24VDC	6.0 to 24VDC
ABSOLUTE MAXIMUM RATINGS — SR3/SR4	Supply Voltage (Vs)		−0.5 to +25VDC	−1.2 to +24VDC
	Voltage Externally Applied to Output (VDC)	OFF only	+25 max.	+24max.
		ON or OFF	−0.5 min.	−0.5 min.
	Output Current (mA)		20	20
	Temperature	Storage/ Operating	−40° to +85°C (−40° to +185°F)	−40° to +85°C (−40° to +185°F)
	Magnetic Flux		No limit. Circuit cannot be damaged by magnetic overdrive.	

ABSOLUTE MAXIMUM RATINGS — SS9	Supply Voltage (Vs)		−0.5 to +14VDC
	Output Current (mA)		10
	Temperature	Storage	−55° to +150°C (−67° to +302°F)
		Operating	−40° to +150°C (−40° to +302°F)
	Magnetic Flux		No limit. Circuit cannot be damaged by magnetic overdrive.

ABSOLUTE MAXIMUM RATINGS — 2AV	Supply Voltage	−40 to +30VDC
	Voltage externally applied to output	+40 VDC max. (OFF condition only) −0.8 VDC min. (OFF or ON condition)
	Output ON current	40 mA for 5 minutes max.
	Temperature range	−40 to +160°C (−40 to +320°F) for 2 hours max.
	Magnetic flux	No limit. Circuit cannot be damaged by magnetic overdrive.

			4.5 to 5.5VDC	6 to 16VDC
ABSOLUTE MAXIMUM RATINGS — 4AV	Supply Voltage		−9.5 to +7.0VDC	−1.2 to +20VDC
	Voltage Externally Applied to Output	OFF only	+15VDC max.	+20VDC max.
		ON or OFF	−0.5VDC min.	−0.5VDC min.
	Load on Output, Continuous		10 mA per output	20 mA per output
	Temperature		−40° to +125°C (−40° to +257°F)	−40° to +125°C (−40 to +257°F)

ABSOLUTE MAXIMUM RATINGS — SS495	Supply Voltage (V_s)	−0.5 to +11VDC
	Output current	10 mA
	Operating temperature	−40 to +150°C (−40 to +302°F)
	Storage temperature	−55 to +165°C (−67 to +329°F)
	Magnetic flux	No limit. Circuit cannot be damaged by magnetic overdrive.
ABSOLUTE MAXIMUM RATINGS — SS100	Supply Voltage	−1 to +30VDC
	Voltage externally applied to output	+30VDC max. (OFF condition only) −0.5VDC min. (OFF or ON condition)
	Output ON current	50 mA max.
	Operating temperature	−40 to +150°C (−40 to +302°F)
	Storage temperature	−55 to +150°C (−67 to +302°F)
	Magnetic flux	No limit. Circuit cannot be damaged by magnetic overdrive.

NOTICE

Absolute maximum ratings are the extreme limits the device will withstand without damage to the device. However, the electrical and mechanical characteristics are not guaranteed as the maximum limits (above recommended operating conditions) are approached, nor will the device necessarily operate at absolute maximum ratings.

PRESSURE SENSORS

MICRO SWITCH pressure sensors are small, low cost and reliable. You can handle a wide range of applications with your choice of the following features and performance characteristics.

- Solid state, piezoresistive integrated circuit sensing
- Pressure ranges from ±2.5″ H_2O to 250 psi
- Absolute, differential or gage measurement
- Amplified output
- Signal conditioning
- Temperature compensation
- Supply voltages from 8 to 16 VDC
- Null and full scale output trim
- PC board, leadwire and cable termination
- Plastic, die-cast aluminum and stainless steel housings
- And some meet MIL standards for shock, vibration, and moisture resistance

20PC Series — Miniature sensors with a unique conductive seal. Versatile, easily modified package.

130PC Series — Measures just over 16mm square and weighs only 5 grams.

140PC Series — Offers amplified output with temperature compensation over a wide range. Includes a current output version that avoids voltage drop problems.

160PC Series — High sensitivity and low pressure measurement from 0-1 psi.

170PC Series — Low level output with high sensitivity from 0-1 psi pressure measurement.

180PC Series — Miniature amplified sensors.

230PC Series — Rugged, corrosion-resistant plastic or stainless steel housing.

240PC Series— Epoxy coated die-cast aluminum housing and O-ring seals for environmental protection.

For further information, request Catalog 15 (84-07908) and pressure sensor product literature.

AIR FLOW SENSING

Sensors that measure mass air flow in 0 to 200 sccm range or differential air pressure in the 0-2″ H_2O range are available. A unique design, referred to as a microbridge, combines advanced thin film and chemical etching techniques. A heater resistor is used in conjunction with temperature sensors to create this dual function sensor. Request Catalog 15 (84-07908) and AWM Series literature.

Solid State Sensors

Current Sink and Current Source Interfacing

Application Notes

NPN AND PNP TYPES

Linear and digital Hall effect are offered in two basic types — NPN (sinking) or PNP (sourcing). A current sinking device (open collector, normally high) "sinks current from a load". Consequently, current flows from the load into the transducer **Figure 1.** A current sourcing device (open emitter, normally low) "sources current into a load" causing current to flow from the transducer into the load **Figure 2.**

The digital Hall effect sensor can be envisioned as a mechanical switch which allows current to flow when turned on and blocks current flow when turned off. The transducer will only switch low level DC voltages (30 VDC maximum) at currents of 40mA or less. The linear Hall effect transducer puts out a continuous signal proportional to the sensed magnetic field.

INTERFACES

Conditions that must be met when interfacing with digital Hall effect sensors are: (1) the interface must appear as a load that is compatible with the output, and (2) the interface must provide the combination of current and voltage required in the application.

PULL-UP AND PULL-DOWN RESISTORS

A pull-up resistor must be used with a current sinking device and a pull-down resistor for current sourcing devices. The outputs are floating, therefore the pull-up or pull-down resistor helps establish a solid quiescent voltage level. These resistors also minimize the effect of small leakage currents from the output of the device or from the electronics with which the transducer is interfaced. Additionally, they provide better noise immunity and faster rise and fall times.

A pull-up resistor is connected directly across the positive terminal (+ supply) and output (0). When the device is deactuated, the input to the load is "pulled-up" to near V_{Supply}. In other words, a current sinking device will output a voltage equal to the supply voltage when it is in a non-operated state. In addition, it will output approximately 0.4 volts in an operated state (output transistor's saturation voltage plus a diode drop).

A pull-down resistor is connected directly across the output of the device and the negative terminal (ground). When the transducer is actuated, the input to the load rises to near V_{Supply} independent of the pull-down resistor. Conversely, when the device is deactuated, the input to the load is "pulled-down" to near ground potential. When selecting a pull-up or pull-down resistor, it must be determined if the interface will tolerate a resistance in parallel. If there is a parallel resistance, the total resistance and load current should be calculated to make sure the Hall effect transducer's output current will not be exceeded.

APPLICATION DATA

Solid State Sensors

Current Sink and Current Source Interfacing

Figure 1
Current Sinking Outputs

The schematics shown are typical of the outputs with which MICRO SWITCH Hall effect sensors can be interfaced. Values shown are representative only.

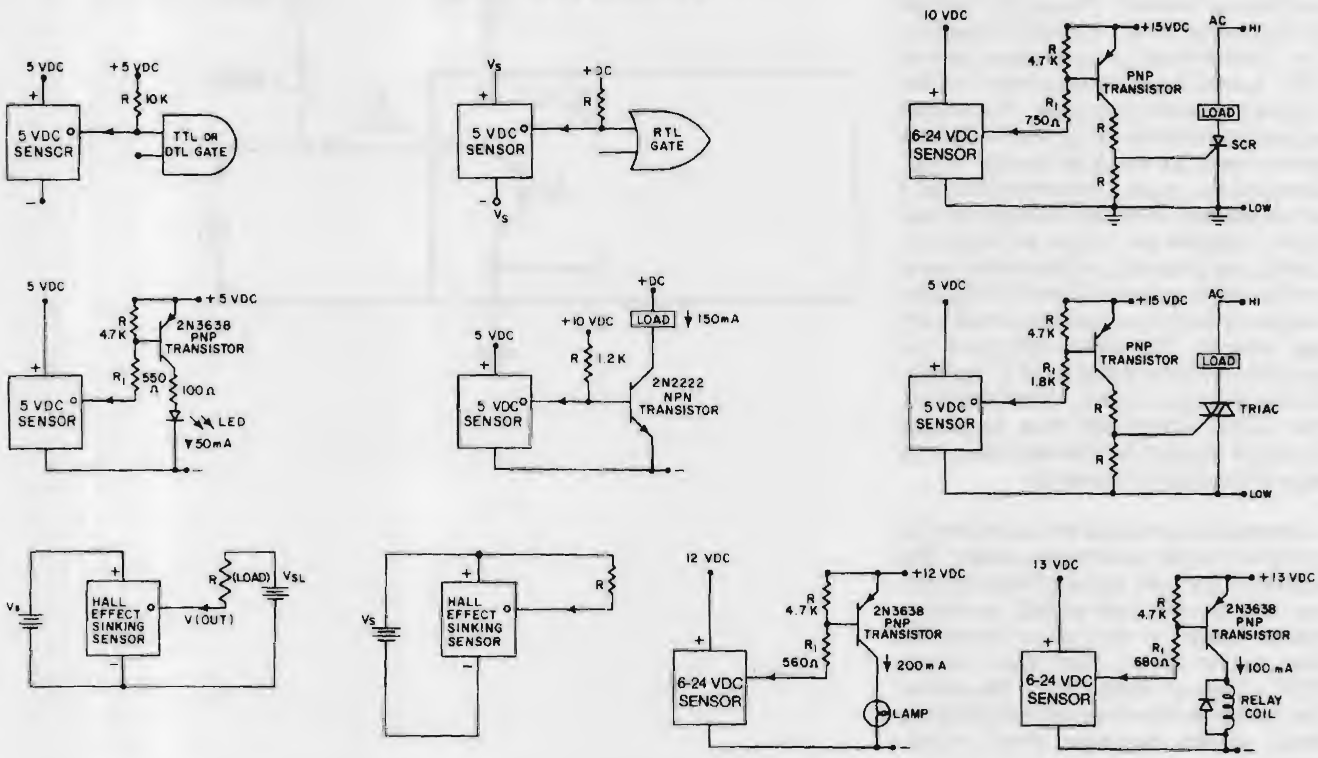
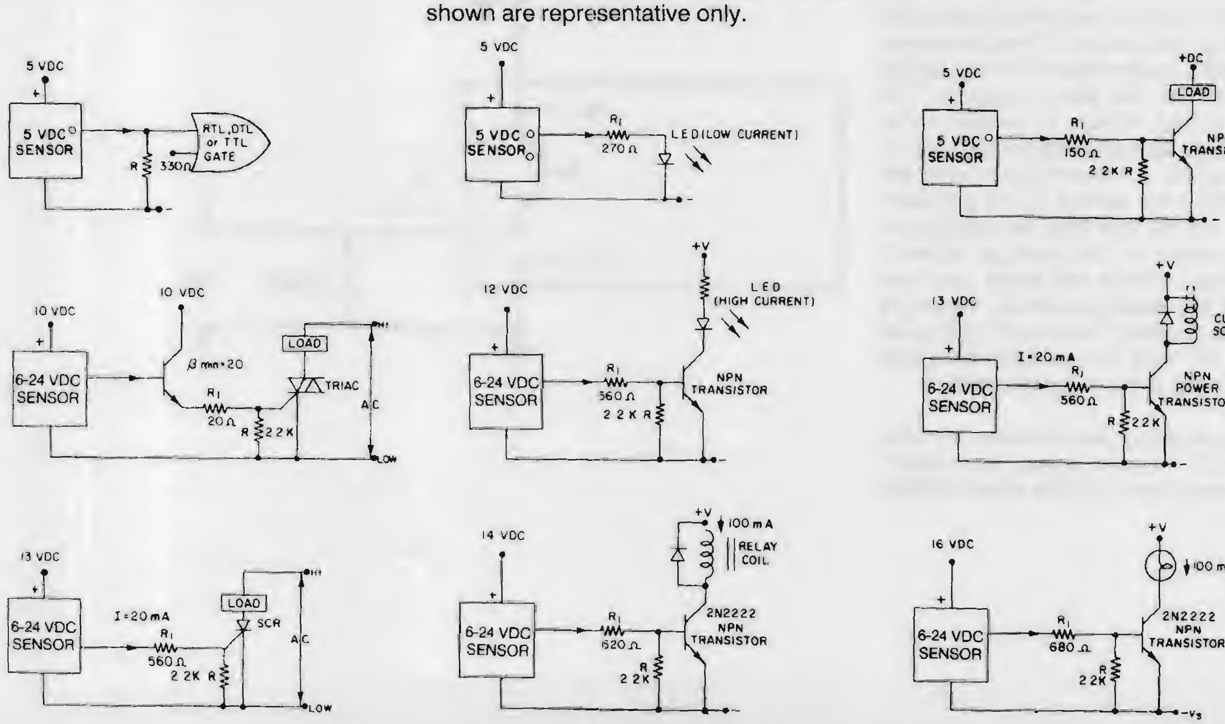


Figure 2
Current Sourcing Outputs

The schematics shown are typical of the outputs with which MICRO SWITCH Hall effect sensors can be interfaced. Values shown are representative only.

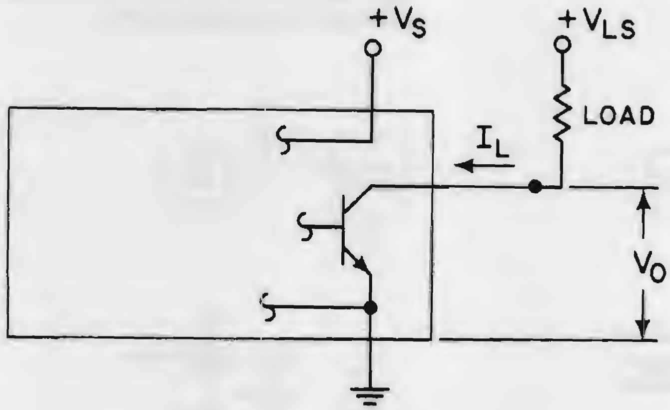


CURRENT SINKING OUTPUT

Figure 3 represents the output stage of a typical current sinking sensor. In this circuit configuration, the load is generally connected between the supply voltage and output terminal (collector) of the sensor. When the sensor is actuated (turned ON), current flows thru the load, into the output transistor to ground. The supply voltage of the sensor (V_S) need not be the same value as the load supply (V_{LS}); however, it is usually convenient to use a single supply. The output voltage is measured between the output terminal (collector) and ground (-). When the sensor is not actuated, current will not flow thru the output transistor (except for a small leakage current). The output voltage, in this condition, will be equal to V_{LS} (neglecting the leakage current). When actuated, the output voltage will drop to ground potential (except for the saturation voltage of the output transistor).

Current sinking derives its name from the fact that it "sinks current from a load." The current flows from the load into the sensor. Like a mechanical switch, the sensor allows current to flow when turned-ON and blocks current flow when turned-OFF. Unlike an ideal switch, the sensor has a voltage drop when turned-ON and a small current (leakage) when turned-OFF.

Figure 3
Typical Current Sinking Output Circuit

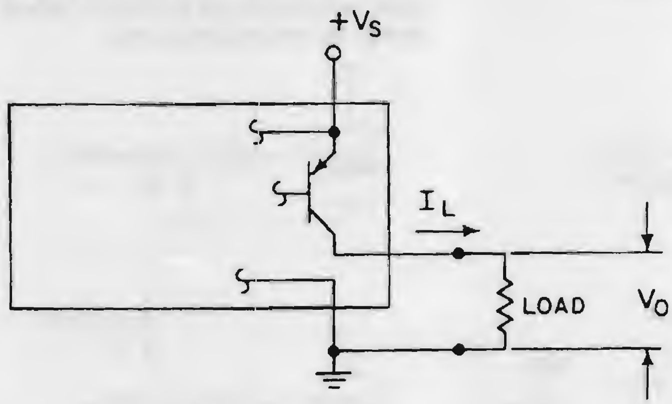


CURRENT SOURCING OUTPUT

Figure 4 represents the output stage of a typical current sourcing sensor. In this circuit, the load is generally connected between the output terminal (collector) of the sensor and ground. When the sensor is actuated, current flows from the output transistor into the load to ground. The sensor output voltage is measured between the output terminal and ground (-), and is equal to the voltage across the load. When the sensor is not actuated, current will not flow thru the output transistor (except for the leakage current). The output voltage will equal zero (neglecting the leakage current). When the sensor is actuated, the output voltage will rise to V_S less the collector-to-emitter voltage drop of the output transistor.

Current sourcing gets its name from the fact that it "sources current to a load." The current flows from the sensor into the load.

Figure 4
Typical Current Sourcing Output Circuit



Application Note

Two additional combinations of transistor interfaces can be realized with current sourcing and current sinking sensors. These are:

- Current sinking sensor with a current sourcing drive
- Current sinking sensor with a current sinking drive

The design equations necessary to choose the correct bias resistors and drive transistors for the first two are shown in Figures 5 and 6.

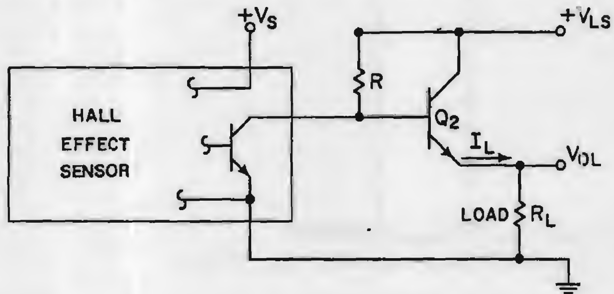


Figure 5 Sinking sensor – sourcing output

R for a given sensor:

$$R_{min} = \frac{V_{LS} - V_{CE(Q1)}}{I_{ON}}$$

R for adequate load current:

$$R_{max} = \frac{(\beta_{min} + 1)(V_{LS} - R_L I_{L(max)}) - B_{BE(ON)}}{I_{L(max)}}$$

If $R_{max} \leq R_{min}$ then use either a transistor with a higher β or a second amplifier stage.

β_{min} for given R:

$$\beta_{min} = \frac{RI_{L(max)}}{V_{LS} - R_L I_{L(max)} - V_{BE(ON)}}$$

Output voltage:

$$V_{OL} = \frac{V_{LS} - V_{BE(ON)}}{1 + \frac{R}{RL\beta + RL}}$$

Transistor output requirements:

$I_{L(max)} < I_{C(max)}$
$V_{LS} < BV_{CER}$

Transistor power dissipation:

$$P_D = I_L(V_{LS} - V_{OL}) = \frac{\frac{R_{VLS}}{R_L\beta + R_L + V_{BE(ON)}}}{1 + \frac{R}{R_L\beta + R_L}}$$

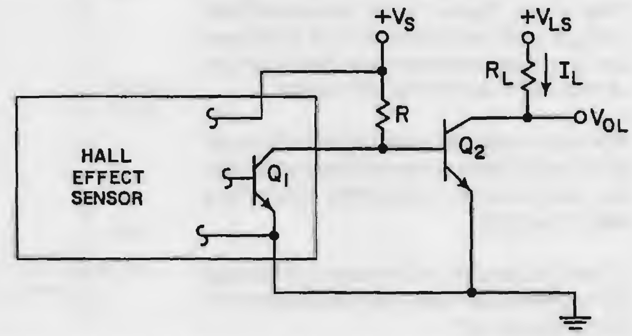


Figure 6 Sinking sensor – sinking output

R for given sensor:

$$R_{min} = \frac{V_S - V_{CE(Q1)}}{I_{(ON)}}$$

R for adequate load current:

$$R_{max} = \frac{\beta_{min}(V_S - V_{BE(ON)})}{V_S - V_{BE(ON)}}$$

If $R_{max} \leq R_{min}$ then use either a transistor with a high β or a second amplifier stage.

β_{min} for given R:

$$\beta_{min} = \frac{RI_{L(max)}}{V_S - V_{BE(ON)}}$$

Output voltage:

$V_{OL} = V_{CE(SAT)Q2}$ for I_L

A minimum β of 10 is recommended for good saturation voltage.

Transistor output requirement:

$I_{L(max)} < I_{C(max)}$
$V_{LS} < BV_{CER}$

Transistor power dissipation:

$$P_D = V_{OL} \bullet I_L$$

Solid State Sensors

Interpreting Operating Characteristics

INPUT CHARACTERISTICS

The input characteristics of a digital output Hall effect sensor are defined in terms of an operate point, release point, and differential. Since these characteristics change over temperature, and from sensor to sensor, they are specified in terms of maximum and minimum values.

Maximum operate point refers to the level of magnetic field which will insure the digital output sensor turns ON under any rated condition.

Minimum release point refers to the level of magnetic field that insures that the sensor is turned OFF.

Figure 1

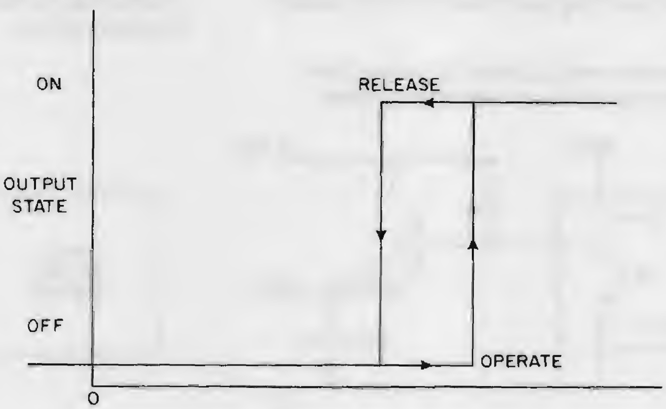
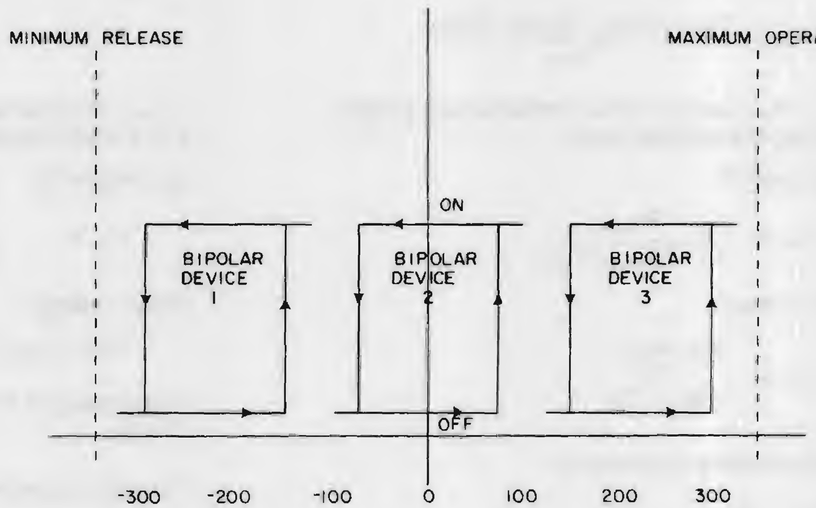


Figure 1 shows the input characteristics for a typical unipolar digital output sensor. The sensor shown is referred to as unipolar since both the maximum operate and minimum release points are positive.

Figure 2



A bipolar sensor has a maximum operate point which is positive and a minimum release point which is negative. The transfer functions are illustrated in **Figure 2.** Note that there are three combinations of actual operate and release points possible with a bipolar sensor. This is not a true latching bipolar device. A latching bipolar device, over the entire temperature range, would always have a positive operate point and a negative release point.

Solid State Sensors

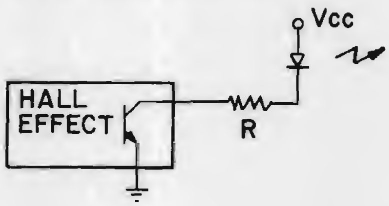
Interfacing Digital Hall Effect Sensors

Hall effect sensors can be interfaced in many types of applications. This application note discusses the interfacing required for a few basic applications.

DRIVING AN LED INDICATOR

The simplest interface is that shown for driving an LED indicator **(Figure 1).** The resistor R must limit current through both the output transistor of the Hall transducer and the LED.

Figure 1
Driving an LED Indicator



$$R_{MN} \quad \frac{V_{CC} + V_{FLED} + V_{CE(SAT)}}{R} \quad I_{C\,MAX}$$

Where:

V_{FLED} is forward voltage drop of LED
$V_{CE(SAT)}$ is voltage drop of output transistor
$I_{C\,MAX}$ is rated current of output transistor

DIRECTION DETERMINATION

Two Hall effect sensors may be used to determine direction in a rotational application. The two are located close together, relative to the circumference of the rotating magnet **(Figure 2).** If the magnet rotates in the direction shown, the time for the South poles to pass between S1 and S2 will be short compared to the time to pass between S2 and S1. When direction is reversed, the time relationship is also reversed. **Figure 3** illustrates an implementation.

Figure 2
Rotational Direction

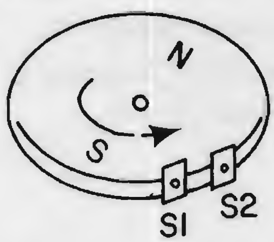
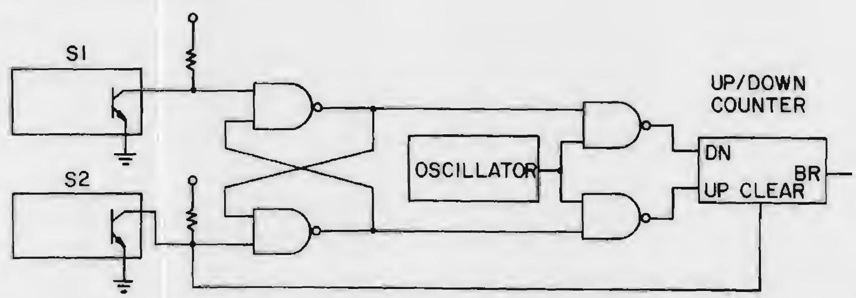


Figure 3
Up/down Counter



Starting at S2, the counter will count "up" oscillator pulses between S2 and S1, and count "down" oscillator pulses between S1 and S2. There will not be an output at the borrow terminal of the counter if the direction is as shown in **Figure 2.** If direction is reversed, there will be a pulse train out.

Hall effect transducers may also be used to control large signals and power by interfacing to a relay (**Figure 4**), an SCR (**Figure 5**), or a TRIAC (**Figure 6**). These are simple applications of the transistor interface previously discussed.

Figure 4
Relay Interface

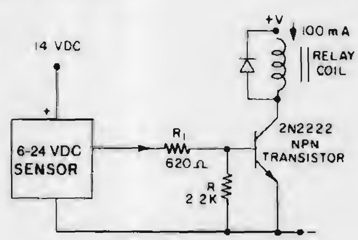


Figure 5
SCR Interface

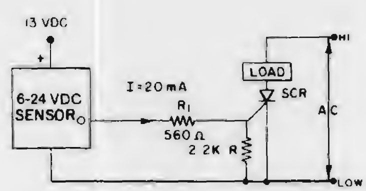
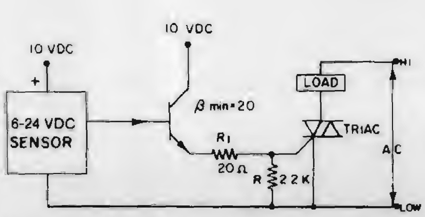


Figure 6
TRIAC Interface



Solid State Sensors

Applying Linear Output Hall Effect Transducers

INTRODUCTION

The SS9 Series Linear Output Hall Effect Transducer (LOHET™) provides mechanical and electrical designers with significant position and current sensing capabilities. Sensor characteristics and applications are discussed in this section.

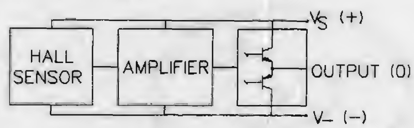
SENSOR DESCRIPTION

Physical dimensions, magnetic characteristics and electrical parameters are covered on page 19.

Figure 2 shows the block diagram of the SS9. The elements which make up these transducers are: a Hall effect element, temperature compensating amplifier and output transistor. Three thick film resistors are incorporated in the design. Sensitivity adjustment and temperature compensation is provided, and one resistor is trimmed for the offset voltage.

Figure 1
Linear Output Hall Effect Transducer (LOHET™)

Figure 2
Block Diagram



Solid State Sensors

Applying Linear Output Hall Effect Transducers

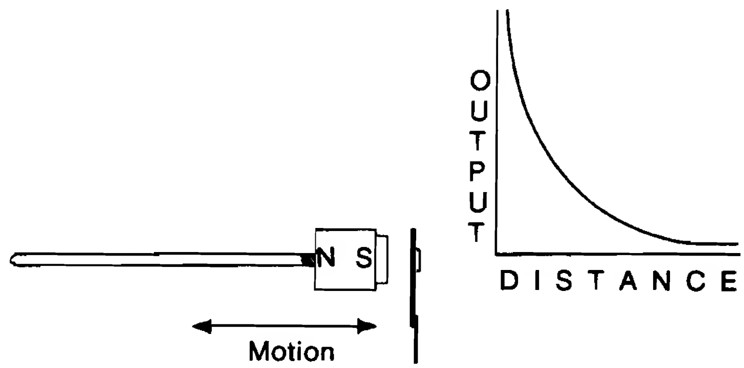
MAGNETICS

The SS9 is magnetically actuated. **Figure 3** through **Figure 6** represent a few of the ways a magnetic system can be presented to the LOHET™ for position measurement. The method of actuation will be determined based upon cost, performance, accuracy and other requirements for a given application.

Head-on sensing

A simple method of position sensing is shown in **Figure 3.** One pole of a magnet is moved directly to or away from the sensor. This is a unipolar head-on position sensor. When the magnet is farthest away from the sensor, the magnetic field at the sensing face is near zero gauss. In this condition, the sensor's nominal output voltage will be six volts with a 12 volt supply. As the south pole of the magnet approaches the sensor, the magnetic field at the sensing surface becomes more and more positive. The output voltage will increase linearly with the magnetic field until a +400 gauss level or nominal output of 9 volts is reached. The output as a function of distance is nonlinear, but over a small range may be considered linear.

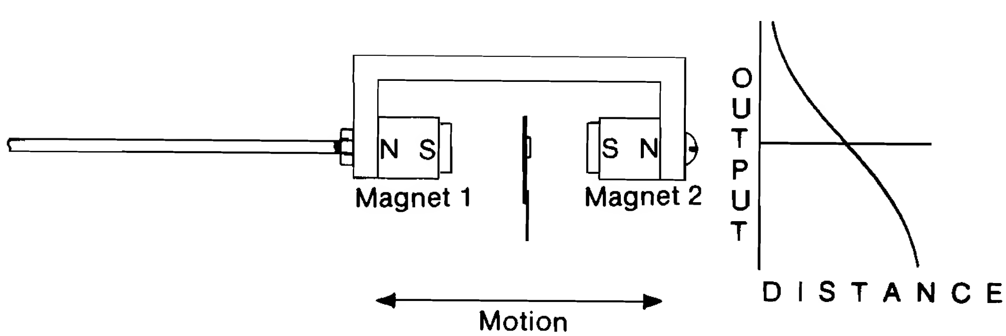
Figure 3
Unipolar Head-On Position Sensor



Bipolar head-on sensing

Bipolar head-on sensing is shown in **Figure 4.** When the magnets are moved to the extreme left, the SS9 is subjected to a strong negative magnetic field by magnet #2, forcing the output of the sensor to a nominal 3.0 volts. As magnet #1 moves toward the sensor, the magnetic field becomes less negative, until the fields of magnet #1 and magnet #2 cancel each other, at the midpoint between the two magnets. The sensor output will be a nominal 6.0 volts. As magnet #1 continues toward the sensor, the field will become more and more positive until the sensor output reaches 9.0 volts. This approach offers high accuracy and good resolution as the full span of the sensor is utilized. The output from this sensor is linear over a range centered around the null point.

Figure 4
Bipolar Head-On Position Sensor

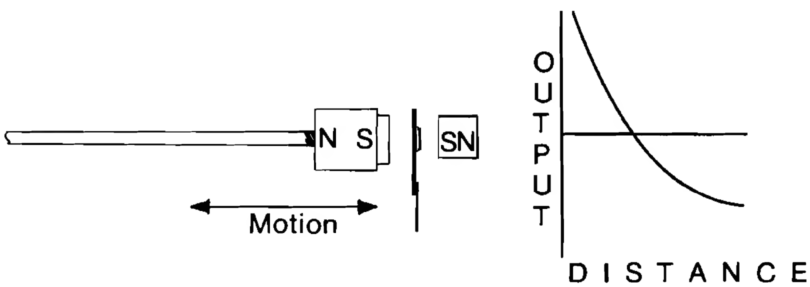


Reference/Index

Biased head-on sensing

Biased head-on sensing, a modified form of bipolar sensing, is shown in **Figure 5.** When the moveable magnet is fully retracted, the SS9 is subjected to a negative magnetic field by the fixed bias magnet. As the moveable magnet approaches the sensor, the fields of the two magnets combine. When the moveable magnet is close enough to SS9, the sensor will "see" a strong positive field. This approach features mechanical simplicity, and utilizes the full span of the SS9.

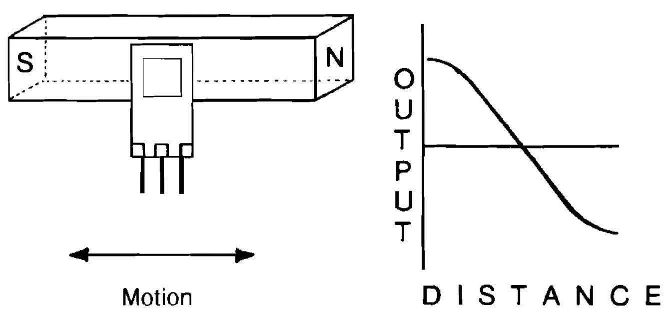
Figure 5
Biased Head-On Position Sensor



Slide-by sensing

Slide-by actuation is shown in **Figure 6.** A tightly controlled gap is maintained between the magnet and the SS9. As the magnet moves back and forth at that fixed gap, the field seen by the sensor becomes negative as it approaches the north pole, and positive as it approaches the south pole. This type of position sensor features mechanical simplicity and when used with a long enough magnet, can detect position over a long magnet travel. The output characteristic of a bipolar slide-by configuration is the most linear of all systems illustrated, especially when used with a pole piece at each pole face. However, tight control must be maintained over both vertical position and gap to take advantage of this system's characteristics.

Figure 6
Slide-By Position Sensor



LINEARIZING OUTPUT

The output of the sensor as a function of magnetic field is linear, while the output as a function of distance may be quite nonlinear as shown in **Figure 3.** Several methods of converting sensor output to one which compensates for the non-linearities of magnetics as a function of distance are possible. One involves converting the analog output of the SS9 to digital form. The digital data is fed to a microprocessor which linearizes the output through a ROM look-up table, or transfer function computation techniques. A second method involves implementing an analog circuit which has the necessary transfer function to linearize the sensor's output. **Figure 7A** diagrams the microprocessor approach, and **Figure 7B** diagrams the analog circuit approach.

Figure 7A
Microprocessor Linearization

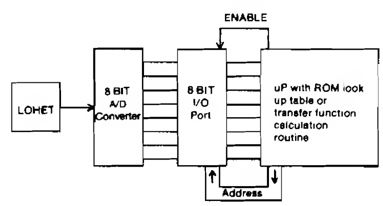
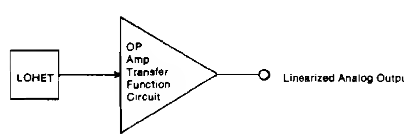


Figure 7B
Analog Linearization



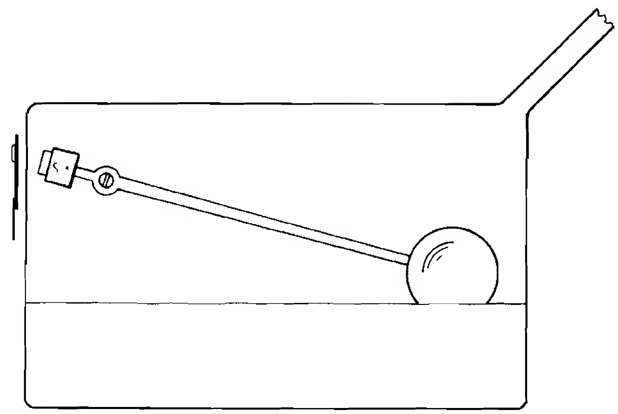
A third method for linearizing the SS9 output can be realized through magnetic design by altering the geometry and position of the magnets used. These types of magnetic assemblies are not normally designed using theoretical approaches. In most instances, it is easier to design magnetics empirically by measuring the magnetic curve of the particular assembly. By substituting a calibrated Hall element for the variety of magnetic systems available, the designer can develop systems which perform a wide variety of sensing functions.

SENSOR APPLICATIONS

Liquid level measurement

Determining the height of a float is one method of measuring the level of liquid in a tank. **Figure 8** illustrates an arrangement of a LOHET and a float in a tank made of non-ferrous material (aluminum). As the liquid level goes down, the magnet moves closer to the sensor, causing an increase in output voltage. This system allows liquid level measurement without any electrical connections inside the tank.

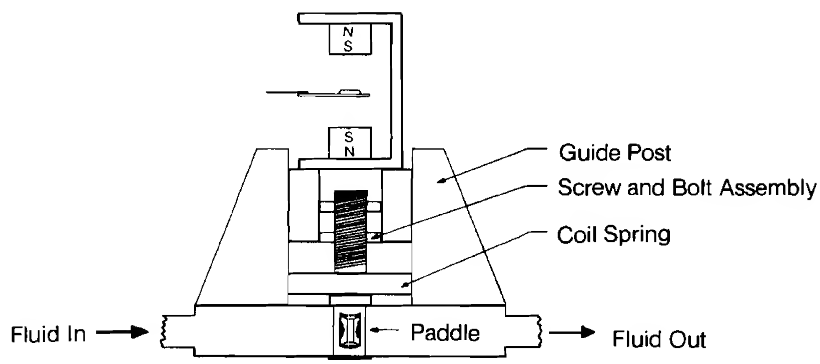
Figure 8
LOHET™ Float Height Detector



Flow meter

Figure 9 shows how LOHET could be used to make a flow meter. As the flow rate through the chamber increases, a spring loaded paddle turns a threaded shaft. As the threaded shaft turns, it raises a magnetic assembly that actuates the sensor. When flow rate decreases, the coil spring causes the assembly to lower, reducing the output. The magnetic and screw assemblies of the flow meter are designed to provide a linear relationship between the measured quantity, flow rate, and the output voltage of the sensor.

Figure 9
LOHET™ Float Meter



Current sensing

LOHET sensors need not be used exclusively with permanent magnets. Since the magnetic field in an unsaturated electromagnet varies linearly with current, a LOHET may be used to sense current. **Figure 10** illustrates a simple current sensor. The coil around the torroid is placed in series with the line and the sensor is placed in the gap. The magnetic field in this gap varies linearly with current, thus producing a voltage ouput proportional to the current. This type of sensor could be used in applications such as a motor control with current feedback.

The magnetic field in an electromagnet is not only a function of current, but also of the number of turns on the core. If the current to be measured is greater than 30 amperes, a single turn design can be used, such as shown in **Figure 11.** This type of sensor is particularly useful in high current systems where broad dynamic range, low series resistance, and a linear current measurement are required.

Figure 10
LOHET™ Current Sensor

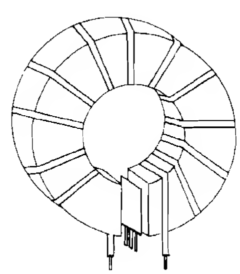
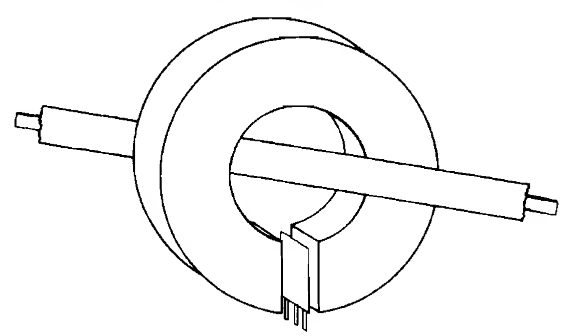


Figure 11
LOHET™ High Current Sensor



Solid State Sensors

Applying Linear Output Hall Effect Transducers

Magnetics

Figure 12 is a semi-logarithmic graph of gauss versus distance for various bar magnets. Each curve is from a single magnet in the head-on mode of operation. The most stable operation at any given distance is obtained by using the magnet that provides the greatest rate of change in gauss at that distance. The best accuracy for any give magnet in the head-on mode of operation is at 400 gauss (40.0 mT).

Although the output is linear as a function of magnetic field, it is not linear as a function of distance. Therefore, the head-on mode of operation does not provide a linear output voltage versus distance. In an application requiring use of the head-on mode of operation, a microcomputer with a look-up table can be used to convert the LOHET™ output to a linear voltage.

Gauss patterns for typical ring magnets are shown in **Figures 13A and 13B.** There is an angular distance around zero gauss level where the gauss versus degrees of rotation approaches linearity. The number of poles on the magnet determines the number of degrees of rotation where this relationship holds true. The spacing between the magnet and the sensor determines the gauss level at which the relationship between gauss and degrees is most linear.

Figure 12

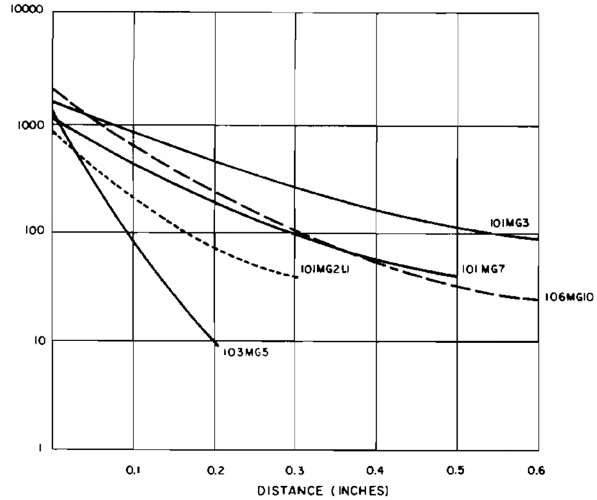


Figure 13A

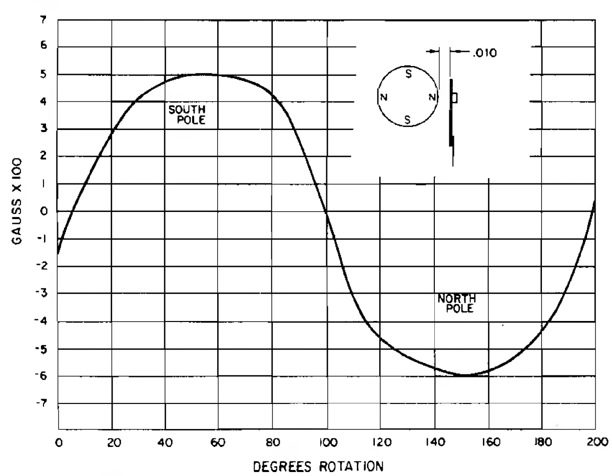
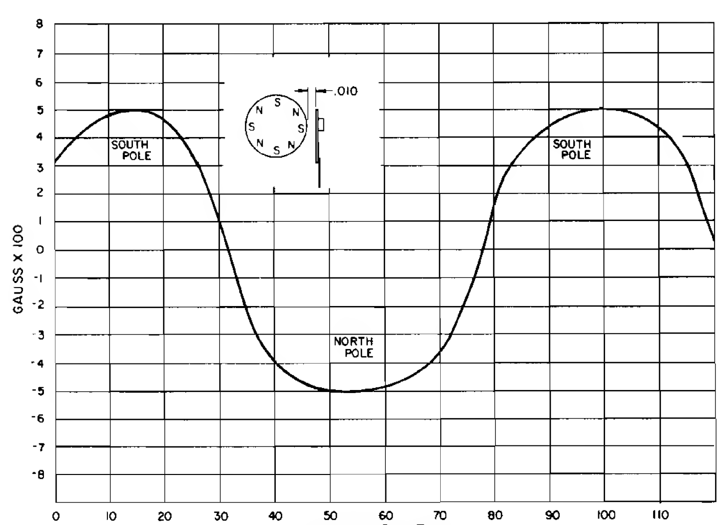


Figure 13B



Solid State Sensors

Applying Linear Output Hall Effect Transducers

Figure 14 illustrates the use of two magnets to obtain a linear relationship between distance and gauss. The distance over which the relationship is most nearly linear depends on the magnets used, and the gap length between the magnets. The assembly in **Figure 14** moves perpendicularly to the LOHET™. If travel is limited to prevent the magnets from touching the LOHET™, the assembly can be used in angular measurements. Non-magnetic material such as aluminum or brass should be used for the magnet mounting bracket.

Two-magnet arrangements are also shown in **Figure 15A and 15B.** The spacing between the magnets and the LOHET™ must be held constant for repeatable operation. Curves are shown for several gap spacings between the magnets and the LOHET™. These assemblies are most useful when a high rate of change in gauss over a short travel is required.

Figure 14

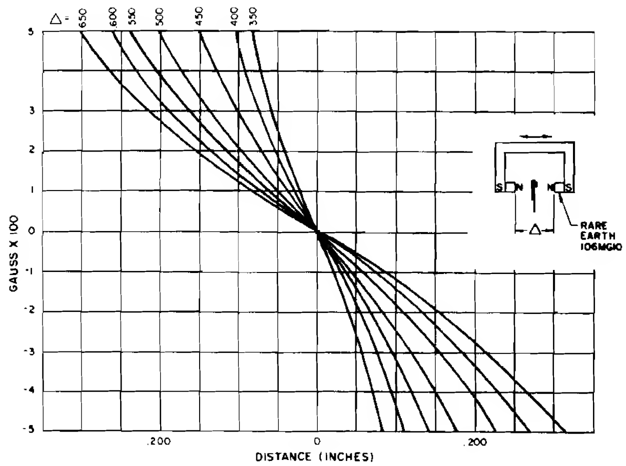


Figure 15A

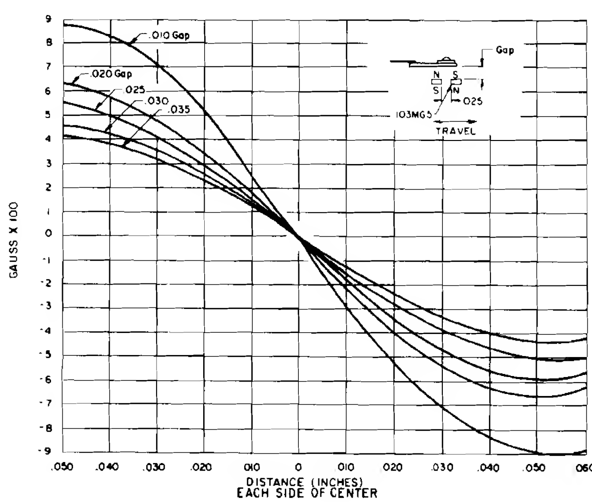
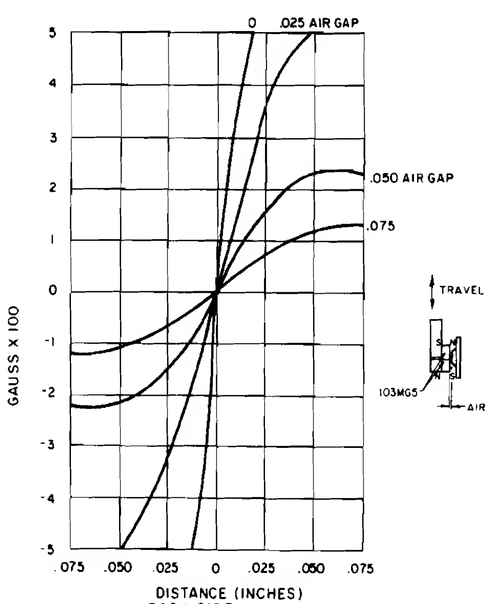


Figure 15B



Applying Linear Output Hall Effect Transducers

Relatively long distances with a linear relationship can be realized with the arrangement shown in **Figures 16A and 16B.** The pole piece (flux concentrator) mounted behind the LOHET™ should be equal to or greater than twice the length of the magnet. The pole pieces at each end of the magnet extend above the magnet. The area of extension is approximately 35% of the cross sectional area of the magnet. The magnet is usually 50% longer than the distance over which the linear relationship is desired. The relative sizes of the parts are shown in **Figure 16A and 16B.**

By using precisely placed magnets, the arrangements shown in **Figures 15 and 16** allow accurate measurement over a short distance when total travel is large, as shown in **Figure 17.**

Figure 16A

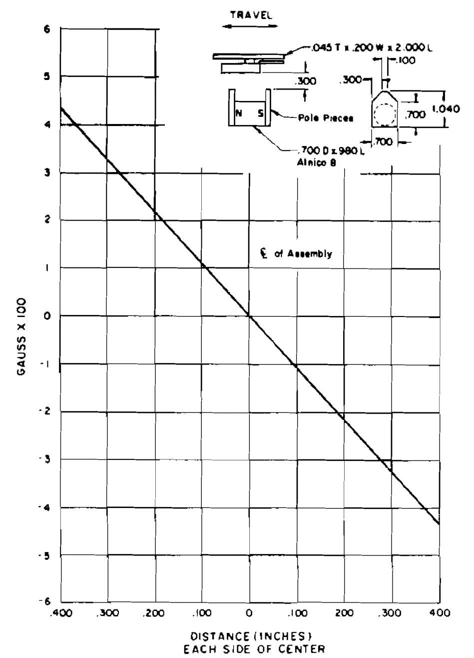


Figure 16B

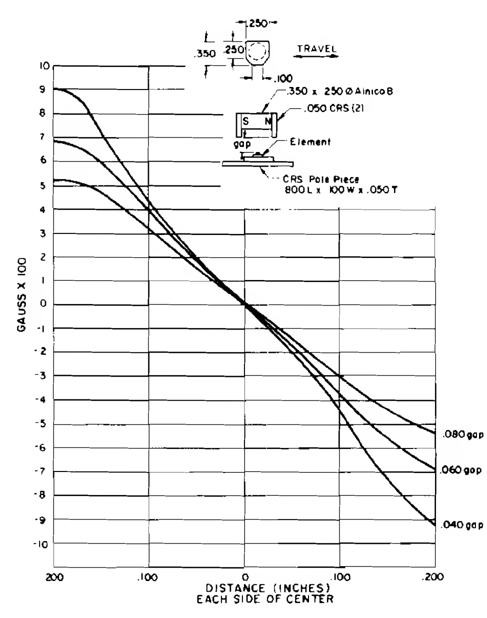
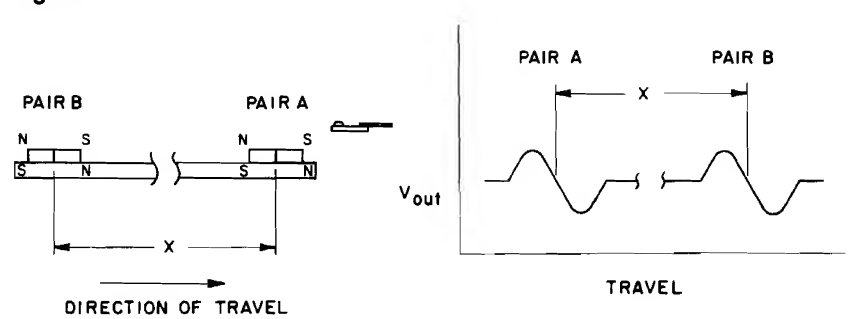


Figure 17



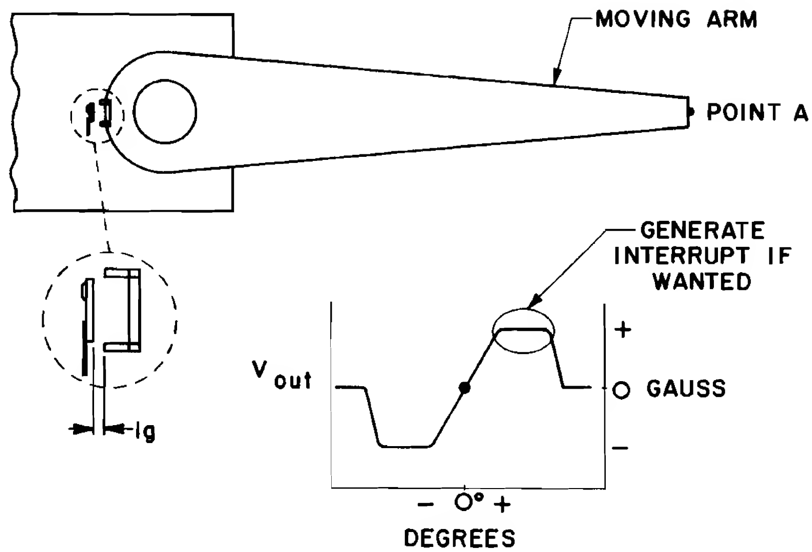
APPLICATION
An arm is rigidly attached to a shaft that rotates 90° **(Figure 18).** The movement of the arm is rapid until it approaches the final position. Then it is to move slowly to the exact position required. A microcomputer based control system is used.

Solution
At zero gauss (center point of the magnet), the variations of Ig due to setup will not change the gauss level. When the arm rotates the full 90°, the gauss level at the LOHET™ will be zero.

1. At some time during the machine cycle, when the magnet is away from the LOHET™, read the voltage through an A/D converter (either on board the computer, or a separate device). This reading serves as the reference for this cycle.
2. Monitor the output voltage during the cycle or generate an interrupt as the zero degree point is approached.
3. When the linear region is reached, the output voltage can be converted by the microcomputer to degrees rotation or distance, as desired.
4. When the LOHET™ output voltage matches the reference from step 1, the arm is at the desired point.

This method provides continuous calibration so that any changes due to temperature variations of the A/D conversion or of the LOHET™, do not influence the measurement. An electromagnet driven by the microcomputer can be used in place of the permanent magnet.

Figure 18



Solid State Sensors

Using SS9 LOHET™ Specifications

INTRODUCTION

This application note discusses the product specifications and how to apply LOHET™ under varying conditions.

USING THE SPECIFICATIONS

The output voltage, **as a function of magnetic field,** is linear over an input range of −400 to +400 gauss (B). Magnet orientation to the LOHET™ for positive and negative gauss notation is shown in **Figure 1.** The South magnetic pole provides positive gauss. North magnetic pole provides negative gauss. North pole, for a freely suspended magnet, points to the geographic north pole.

Figure 2 explains linearity definitions using the end point method. Sensitivity for the SS94A1 is:

$$S = \frac{V_O \text{ (at } +500 \text{ gauss)} - V_O \text{ (at } -500 \text{ gauss)}}{1000}$$

V1 is the null offset (output voltage at zero gauss input). Linearity is the deviation in the output voltage from a straight line, expressed in percent of span. Total output voltage of any device is then V_O = V1 + SxB.

Note: With ratiometric devices, span, null and sensitivity must be calculated if the supply voltage is other than the 12V used to establish the specifications.

The SS94A1 will clamp at 9.0V min. (9.5V typical).

Figure 3 shows the possible changes in null offset (V1) due to changes in ambient temperature. The initial value of V1 can be modified by external circuitry (provided by the customer). Variations in null offset effectively move the total curve in **Figure 2** up or down.

For application help: call 1-800-537-6945.

Figure 1
Magnet Polarity

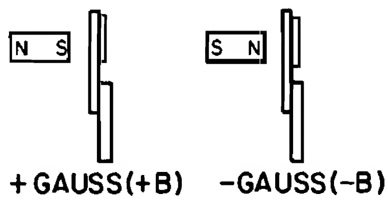


Figure 2 SS94A1 characteristics

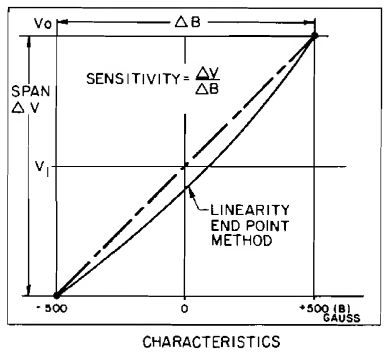
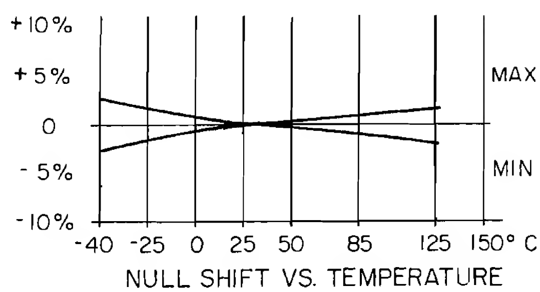


Figure 3
Null Shift vs. Temperature



Solid State Sensors

Using SS9 LOHET™ Specifications

Figure 4 compares output voltages with various values of gauss and sensitivity. The null tolerances must be added to get total span tolerance. **Figure 5** shows the effects of the total temperature range on sensitivity as a percentage change from initial value.

Linearity as defined for the SS94A1 **(Figure 2b)** is determined by the end points at −500 and +500 gauss. As shown linearity is +0 −1% using this method. If we were to define linearity for this product using a best fit line it would be ±.5%.

Figure 6 illustrates a method of plotting characteristics for a typical position sensing application making the following assumptions:

1. The 91SS12-2 ratiometric listing is used.
2. Input voltage = 12VDC.
3. An external comparator (customer supplied) is used to adjust operate point.
4. Temperature range is +15°C to +50°C.
5. Operating point at 25°C is +300 gauss only.

Figure 4
Output Voltage Comparison

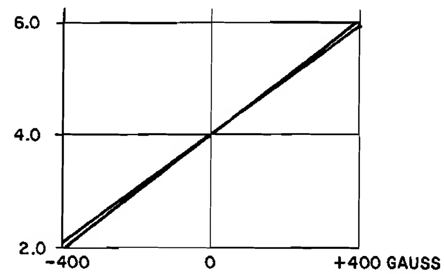


Figure 5
Max Sensitivity Change vs. Temperature

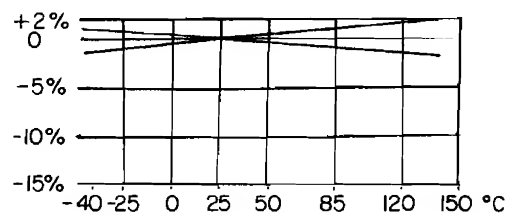
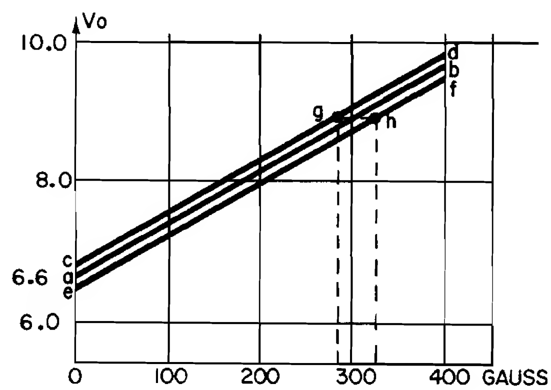


Figure 6
Typical Characteristics Plot



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Using SS9 LOHET™ Specifications

You need to know the worst case gauss limits (minimum and maximum) with temperature change. Calculate characteristics at 12VDC at 25°C and at 50°C (changes at 15°C will be minimal).

If you are drawing a large graph **(Figure 6)**, linearity changes can now be added. The result will be a slight curve in all three lines, with a net effect close to zero.

Line g-h indicates the operating voltage of the external circuit. Points g (285 gauss) and h (327 gauss) are the worst case operating points at 50°C.

Find worst cast gauss (minimum):

S = S max. at 25°C   S′ = S max. at 50°C

B = Op. gauss at 25°C   B′ = Op. gauss at 50°C

$$V1 + S \times B = V1 + \quad V1 + S \times B$$

$$\frac{V1 + S \times B - V1 - \quad V1}{S'} = B'$$

$$\frac{S \times B - \quad V1}{S'} = B'$$

$$\frac{(7.70\text{mV/gauss} \times 300) - (6.60 \times 2\%)}{7.70\text{mV/gauss} \times (100\text{-}1)\%} = B'$$

$$\frac{(.0077 \times 300) - (6.60 \times .02)}{.0077 \times .99} = B'$$

$$\frac{2.31 - .132}{.007623} = 285.71 \text{ gauss (minimum)}$$

Find worst case gauss (maximum):

S = S max. at 25°C   S″ = S min. at 50°C

B = Op. gauss at 25°C   B″ = Op. gauss at 50°C

$$V1 + S \times B = V1 - \quad V1 + S \times B$$

$$\frac{V1 + S \times B - V1 + \quad V1}{S''} = B''$$

$$\frac{S(B) + \quad V1}{S''} = B''$$

$$\frac{(7.70\text{mV/gauss} \times 300) + (6.60 \times 2\%)}{7.70\text{mV/gauss} \times (100\text{-}3)\%} = B''$$

$$\frac{(.0077 \times 300) + (6.60 \times .02)}{.0077 \times .97} = B''$$

$$\frac{2.31 + .132}{.007469} = 326.95 \text{ gauss (maximum)}$$

The shift in gauss (both minimum and maximum) means that at 50°C, the SS9 may require only 285.71 gauss, or possibly as much as 326.95 gauss to operate the comparator. These values can be converted into distance by using the gauss versus distance graphs in the **Magnets** application note.

Similar results can be obtained mathematically, with increased accuracy. For values, refer to the worst case null and sensitivity calculations and **(Figure 6)**.

Worst Case Null and Sensitivity

	at 25°C				
	Min.	**Typ.**	**Max.**	**at 50°C**	**Units**
Null (V1) = 6.0 ±0.6	5.40	6.00	6.60	±2%	Volts
Sensitivity (S) = 7.5 ±0.2	7.30	7.50	7.70	-1% to -3%*	mV/gauss
Linearity ±1.50(+50%)			±2.25	±2.25	%

Calculations

	Point	Value	°C
Null offset (max.) at zero gauss (V1)	a	6.60	25
V1 +S max. × 400 = 6.60 +3.08	b	9.68	25
V1 +2% (V1) = 6.60 +.02 (6.60) = 6.60 +0.132	c	6.732	50
6.732 +(S max. × (100-1)% × 400) = 6.732 +(.0077 × .99 × 400)	d	9.7812	50
V1 -2% (V1) = 6.60 -.132	e	6.468	50
6.468 +(S max. × (100-3)% × 400) = 6.468 +(.0077 × .97 × 400)	f	9.4556	50

* Sensitivity shift at 0°C to 50°C, the maximum value (-0.077%/°C) is specified. Actual range is somewhere between -1% and -3%. For accuracy in calculations, both limits are used (-1% and -3%). (50° -25°C) + (-0.077%/°C) = -1.925%

Solid State Sensors

Interfacing the SS9 LOHET™ With Comparators and OP Amps

INTRODUCTION

This application note covers some common comparator and op amp circuits and their interface with LOHET™. IC manufacturers specification sheets should be consulted when choosing the best op amp or comparator for your application.

Resistor tolerances and temperature coefficients influence overall accuracy. The load resistor (RL) however, is not critical. A ±10% carbon resistor is satisfactory. The load resistor on the LOHET™ output insures that the load is the same as the 2.2 K Ohm load used during LOHET™ manufacture.

COMPARATORS

Figure 1 through **Figure 4** show typical comparator circuits. A single supply LM339 (or equivalent) is used to make a digital switch with adjustable operate point. Hysteresis is provided by resistor RH. In **Figures 1 and 2,** hysteresis is essentially zero, but can be made large enough to provide a latching circuit. Bypass capacitors may be required in some applications, but are not shown on these circuits. The LM339 can provide up to four different switch points per LOHET™. If linear use and digital operation with one LOHET™ is required, an LM124 (or equivalent) op amp may be substituted.

OP AMPS

Figure 5 through **Figure 9** show the LOHET™ interfaced with common single supply op amp circuits. Op amp characteristics limit the output voltage (Vo) equations at high and low ends. The basic circuits can be modified and interconnected (see **Figures 10 and 11**).

The circuit in **Figure 5** can be used with adjustable gain and adjustable offset, although the adjustments will not be completely independent. One method is to adjust the gain to the desired value V1 at approximately one-half Vs. Then, adjust V1 to give the exact offset at Vo required for the application.

Figure 10 illustrates possible gain adjustment by R2 for desired voltage at V2. R5 is then adjusted to provide the desired offset at Vo. Adjustable R values can be provided by potentiometers, fixed resistor combinations, or by laser trimmed thick film resistors.

The basic op amp circuits or circuit combinations will fulfill most LOHET™ use requirements. AC coupling is not shown, but can be used to ground reference AC levels out of the LOHET™. Op amp application data sheets can be obtained from semiconductor suppliers.

Figure 1
Non-inverting

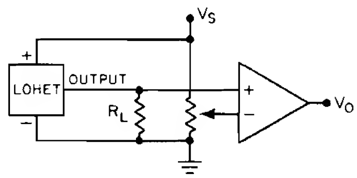


Figure 2
Inverting

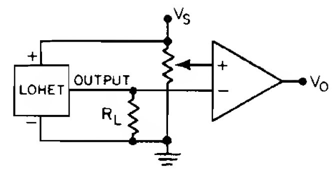


Figure 3
Non-inverting with Hysteresis

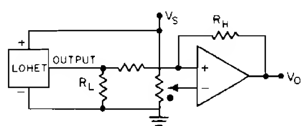


Figure 4
Inverting with Hysteresis

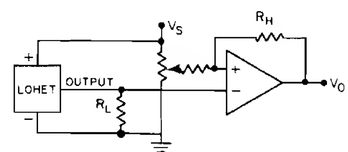
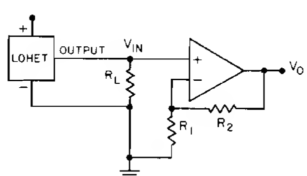
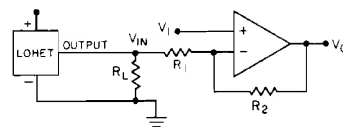


Figure 5
Non-inverting



$$Vo = V_{IN} \left(1 + \frac{R_2}{R_1}\right)$$

Figure 6
Inverting



$$Vo = (V_1 - V_{IN}) \frac{R_2}{R_1} + V_1$$

Figure 7
Voltage Follower

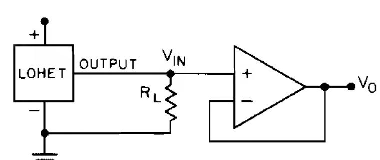


Figure 8
Summing Amplifier with LOHET™ as any Input

$V_o = V_1 + V_2 - V_3 - V_4$ (with all Rs equal)

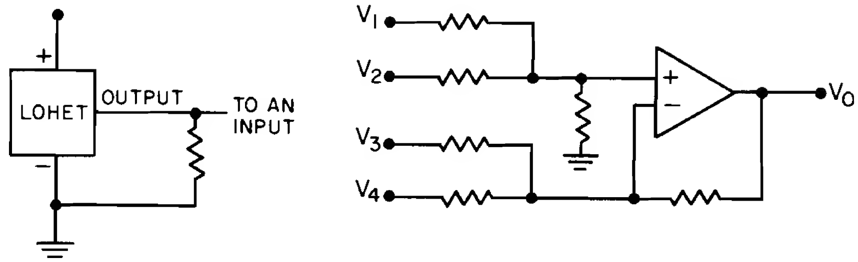


Figure 9
Difference Amplifier

For $R_1 = R_3$ and $R_2 = R_4$,

$$V_o = \frac{R_2}{R_1}(V_{IN}-V_1)$$

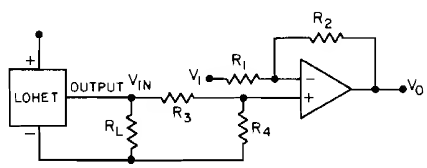


Figure 10
Independent Gain and Offset Adjustments

$$V_2 = (V_1 - V_{IN})\frac{R_2}{R_1} + V_1$$

$$V_O = (V_3 - V_2)\frac{R_4}{R_3} + V_3$$

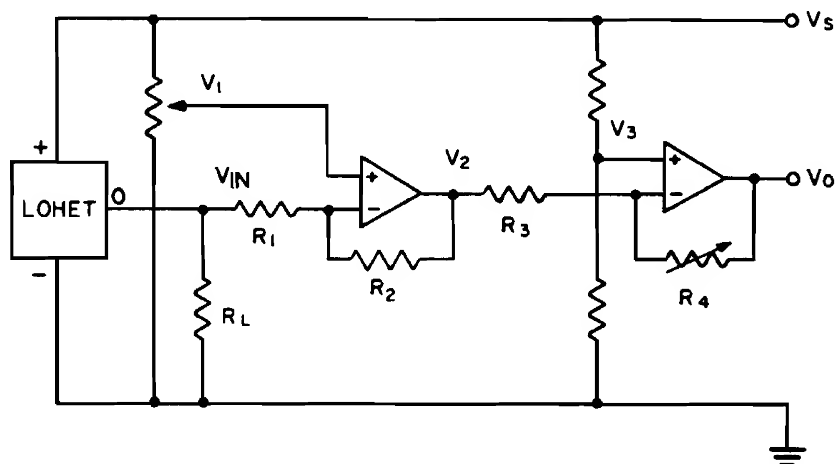
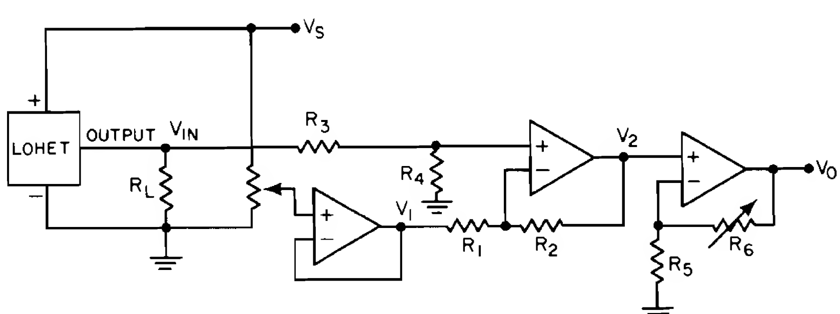


Figure 11
Independent Gain and Offset Adjustments

For $R_1 = R_2 = R_3 = R_4$,

$$V_o = (V_{IN} - V_1)\left(1 + \frac{R_6}{R_5}\right)$$



TEMPERATURE DRIFT COMPENSATION

LOHET™ temperature stability meets most application requirements. Occasionally, however, an application requires extremely tight characteristics. Sorting at use temperature is then necessary. **Figure 12** illustrates a simple method of checking null shift.

Use the same Vs, load and temperature as will be used in the actual application. Set the potentiometer so that the voltmeter reads zero when the LOHET™ is in the 25°C socket. Then move the LOHET™ to the T2 socket, transfer the switch contacts and simply read the null shift directly from the voltmeter. The physical setup is adequate for most requirements.

When null offset temperature drift is known, compensation can be added to the comparator or op amp circuit to temperature stabilize the entire circuit. A thermistor or op amp multiplication of a VBE drop can be used. A VBE multiplier **(Figure 13)** serving as one of the inputs to a summing amplifier is another method.

If sensitivity drift must also be compensated, then measurements must be taken at the use temperature with an applied magnetic field. The number of fixtures required depends on how many different gauss level measurements are needed, and on the number of different temperatures encountered in the application. **Figure 14** shows a simplified drawing of a fixture that can be used for taking these measurements.

Figure 12

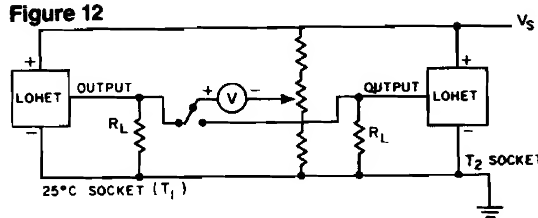


Figure 13

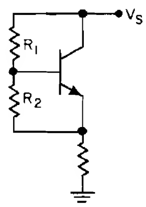
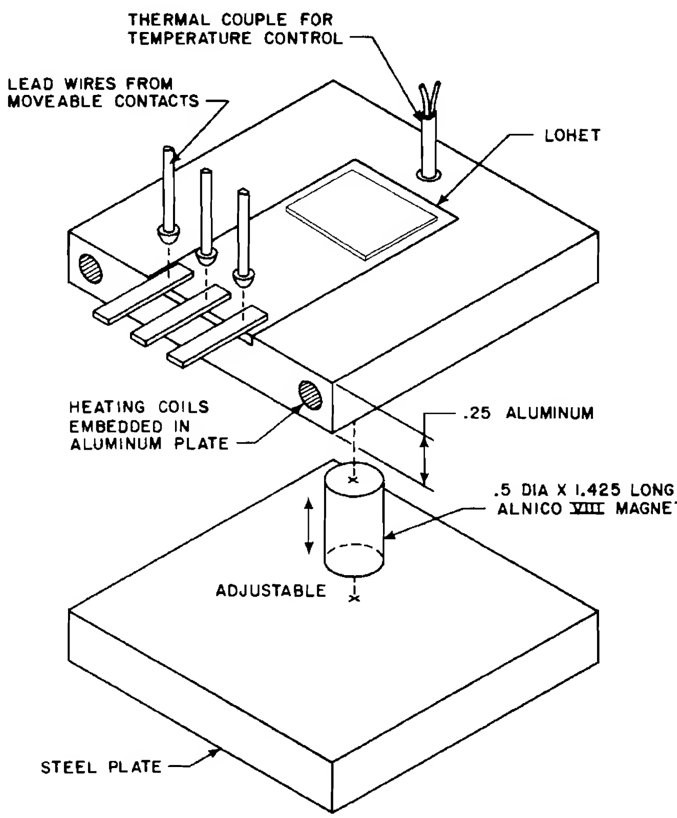


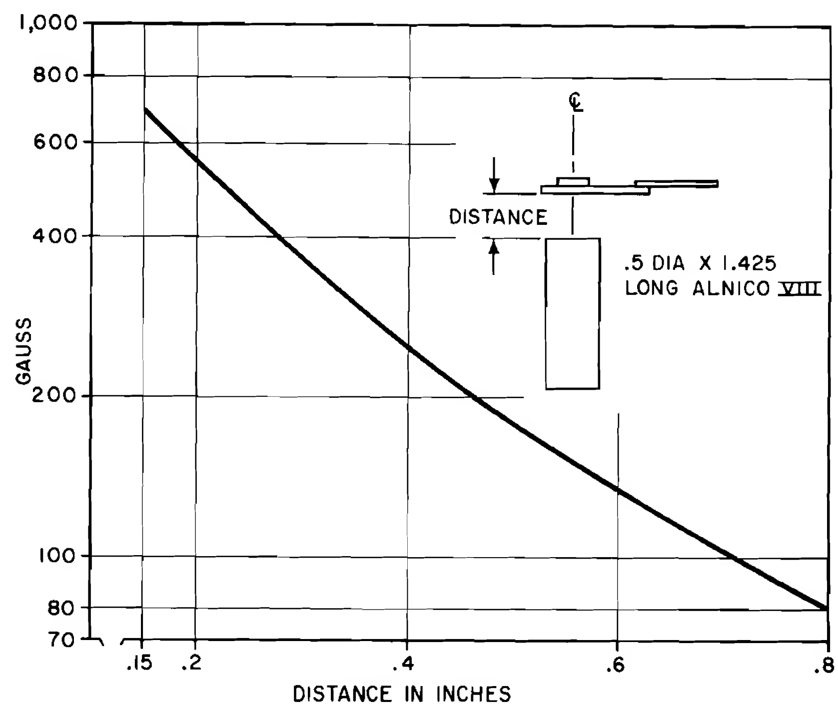
Figure 14



A typical gauss versus distance graph for an Alnico VIII magnet is shown in **Figure 15.** The magnets used in the fixtures should be temperature cycled at least two cycles from –60°C to +200°C (–76°F to +362°F). Thereafter, the temperature coefficient of an Alnico VIII magnet (with the length to diameter ratio shown in **Figure 15**) should be ±.003%/°C. Calibration and adjustments should be made using a Calibrated Hall Element as a substitute for the LOHET. A steel plate below the magnet prevents differences in bench material from influencing the fixture calibration.

Once gain characteristics of a given device or group of devices are known, compensation can be added to the op amp circuit. Common methods are a temperature varying voltage into a summing amp, or a temperature variable resistance as part of the gain determining portion of the op amp configuration.

Figure 15
Gauss vs. Distance



MAGNET MANUFACTURERS
Listed at right is the Dexter Corporation, a magnet manufacturer, and area addresses. The Dexter Corporation should be consulted for specific data on a magnet or material, as well as magnet design assistance.

Area	Address	Phone	Fax
Boston	700 Technology Park Drive Billerica, MA 01821	(978) 663-7500	(978) 663-7503
New York	400 Karin Lane Hicksville, NY 11801	(516) 822-3311	(516) 822-3315
Dallas	855 East Collins Blvd. Richardson, TX 75081	(972) 699-1121	(972) 644-0502
Chicago	1050 Morse Avenue Elk Grove Village, IL 60007	(847) 956-1140	(847) 956-8205
Toledo/Detroit	5580 Monroe Street Sylvania, OH 43560	(419) 885-8331	(419) 885-8117
Silicon Valley	48460 Kato Road Fremont, CA 94538	(510) 656-5700	(510) 668-5422
Los Angeles	18000 Studebaker Rd. Suite 350 Cerritos, CA 90703	(562) 809-3363	(562) 809-4533

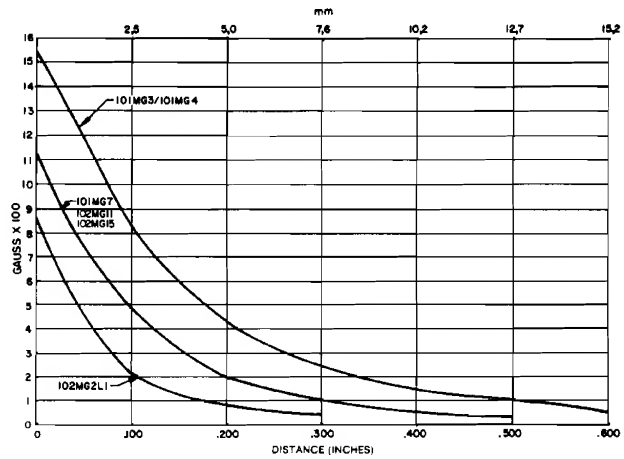
Solid State Sensors

Magnets

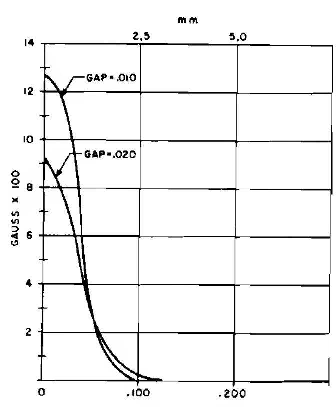
MAGNET CURVES

The curves shown on the graphs are typical plots of induction (gauss) versus distance for various magnets. For more information, contact the 800 number.

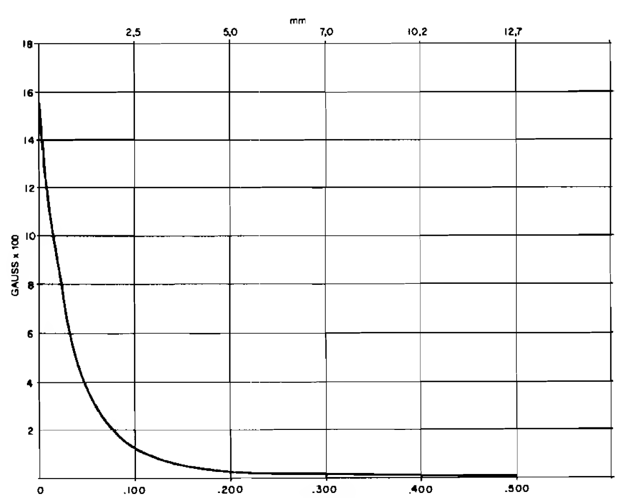
Magnet:
101MG3, 101MG7, 102MG11, 102MG15
101MG2L1
Measured with:
Calibrated Hall Element*
Mode of Operation:
Head-on



Magnet:
103MG5
Measured with:
Calibrated Hall Element*
Mode of Operation:
Slide-by



Magnet:
103MG5
Measured with:
Calibrated Hall Element*
Mode of Operation:
Head-on

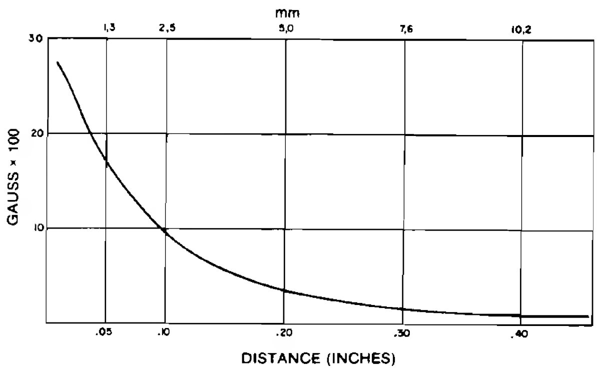


*NOTE:
Calibrated Hall sensors X92755-SS (SS9 type) and X98834-SS (SS4 type) are available to help you measure the magnetic gauss levels in your system. Please contact the 800 number for details.

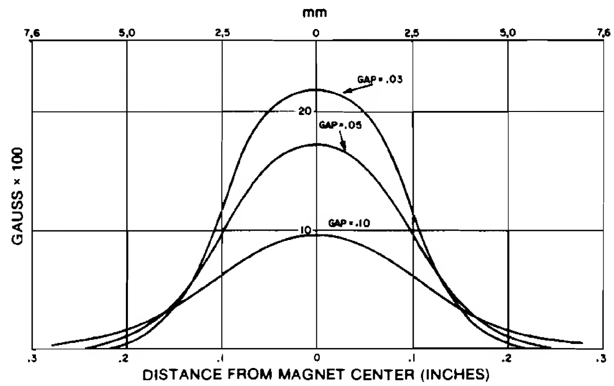
Solid State Sensors

Magnets

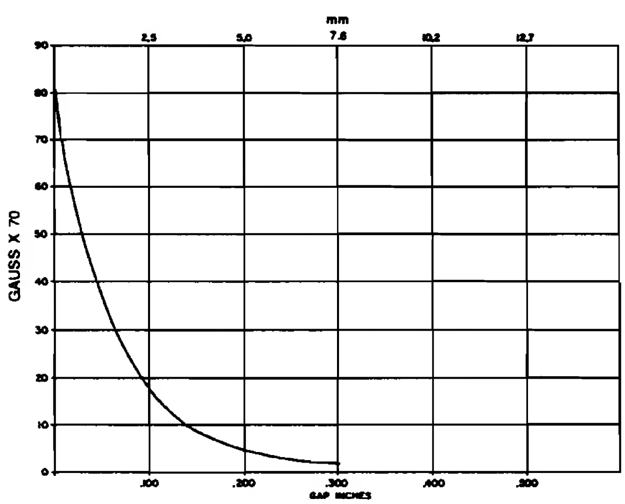
Magnet:
106MG10, 103MG8
Mode of Operation:
Head-on



Magnet:
106MG10, 103MG8
Mode of Operation:
Slide-by



Ring magnet:
105MG5R4
Measured with:
Calibrated Hall Element*
Gap length characteristic at South pole.



DETERMINING MAGNETIC OPERATING CHARACTERISTICS

Magnetic sensing characteristics of Hall effect sensors are specified within particular ranges. For example, assume an application with a temperature range of –40° to 125°C using an SS443A. Referring to the SS400 Order Guide, the operate point may be up to 215 gauss (21.5 mT) and the release point may be 60 to 190 (6.0 to 19.0 mT) gauss. To insure reliable operation, **at least** 215 (21.5 mT) gauss must be presented to the sensor. The gauss level must then be reduced below 60 gauss to insure that the sensor will release. Therefore, it is necessary to know the flux density (gauss) measured at the chip to be able to: (1) select a device with the best magnetic characteristics for your application, (2) select the best magnet, and (3) verify the desired mechanical characteristics.

*NOTE:
Calibrated Hall sensors X92755-SS (SS9 type) and X98834-SS (SS4 type) are available to help you measure the magnetic gauss levels in your system. Please contact the 800 number for details.

Solid State Sensors

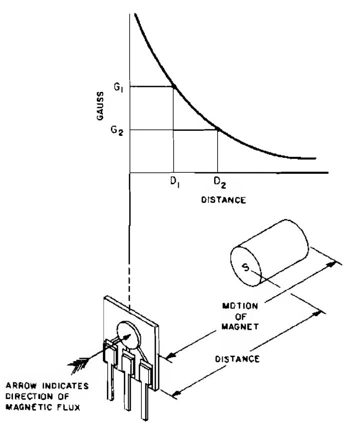
Method of Magnet Actuation

There are many ways to apply Hall effect in position sensing application. The more common methods are described below. Further information is as near as your telephone. Just call your nearest MICRO SWITCH sales office and one of our trained field engineers will be happy to discuss your application with you.

Head-on

For "head-on" actuation, there should be sufficient magnet travel to provide at least 10% flux overdrive of both maximum operate and minimum release characteristics of the sensor. The target is centered over the point of maximum sensitivity and is moved "head-on" to the sensor, then backed off.

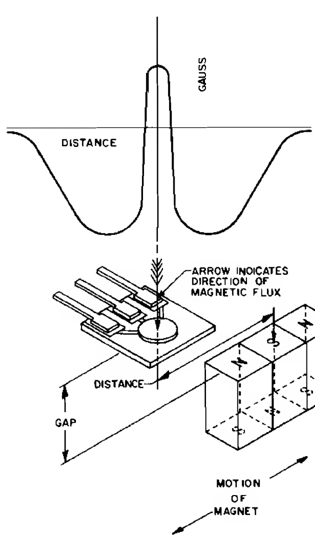
Unipolar Head-on



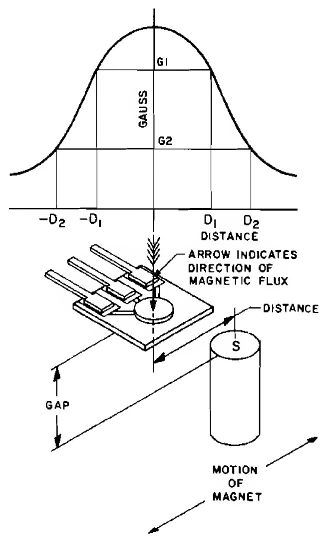
Slide-by

For "slide-by" actuation, the magnet should pass the sensing surface at a distance which provides at least 10% flux overdrive above maximum operate. The target is moved across the face of the sensor at a specified distance.

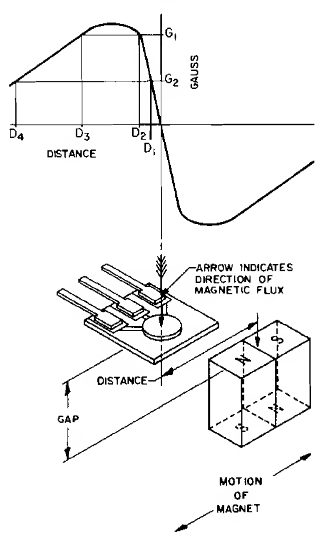
Bipolar Slide-by (3 Magnets)



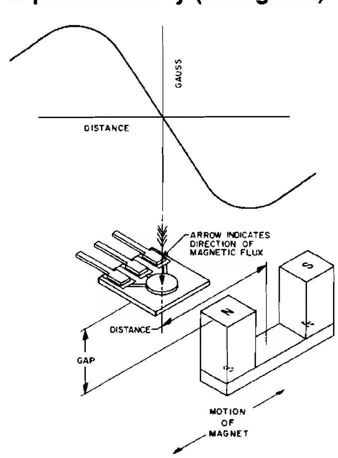
Unipolar Slide-by



Bipolar Slide-by (1 Magnet)



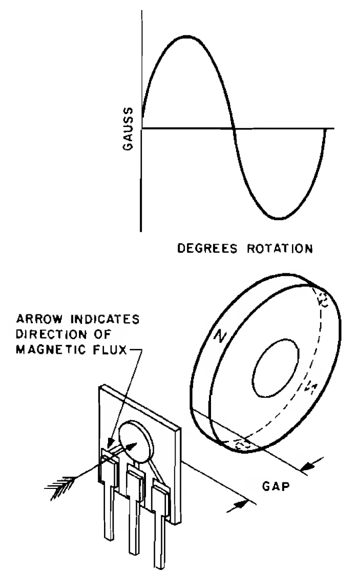
Bipolar Slide-by (2 Magnets)



Rotary

A rotating target, such as a ring magnet, provides an alternating pattern of On-Off actuation.

Bipolar Slide-by (Ring Magnet)



Solid State Sensors

Magnet Conversion Chart

MULTIPLICATION FACTORS

From	Gauss	Tesla	Millitesla	Weber/Inch²	Weber/Meter²	Line/Inch²	Gammas
To: Gauss	1	1×10^{4}	10.0	1.550×10^{7}	1×10^{4}	1.55×10^{7}	1×10^{-5}
Tesla	1×10^{-4}	1	1×10^{-3}	1.5500×10^{3}	1	1.5500×10^{3}	1×10^{-9}
Millitesla	0.1	1×10^{3}	1	1.5500×10^{-4}	1×10^{3}	1.5500×10^{6}	1×10^{-6}
Weber/Inch²	6.4516×10^{-5}	6.4516×10^{-4}	6.4516×10^{-2}	1	6.4516×10^{6}	1	6.4516×10^{-13}
Weber/Meter²	1×10^{-4}	1	1×10^{-3}	1.5500×10^{3}	1	1.5500×10^{3}	1.0×10^{-9}
Line/Inch²	6.4516×10^{-5}	6.4516×10^{-4}	6.4516×10^{-2}	1	6.4516×10^{6}	1	6.4516×10^{-13}
Gammas	1×10^{6}	1×10^{9}	1×10^{6}	1.5500×10^{12}	1×10^{9}	1.5500×10^{12}	1

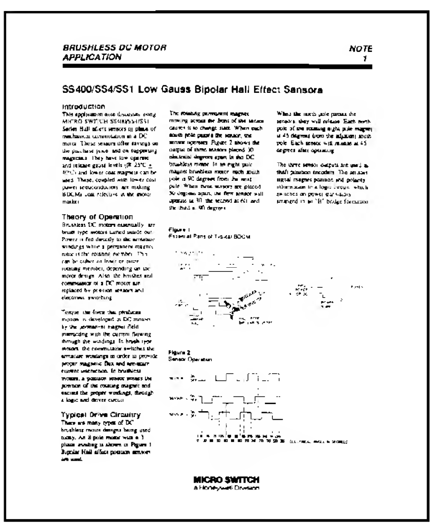
SOME COMMON MAGNETIC MATERIALS

	B_DH_D-Peak Energy Product	(B_R)-Residual Induction Gauss	(H_C)-Coercive Force Oersteds
Barrium Ferrite	1.4×10^{6}	2450	2200
Ceramic	2.6×10^{6}	3350	2350
Alnico V	5.5×10^{6}	12800	640
Alnico VIII	6.0×10^{6}	9200	1550
Rare Earth	18.0×10^{6}	8600	8000

Available solid state sensor literature

Application Note:

Brushless DC Motor Application Note 1
(84-05759)


BRUSHLESS DC MOTOR APPLICATION NOTE 1

SS400/SS4/SS1 Low Gauss Bipolar Hall Effect Sensors

Introduction

Theory of Operation

Typical Drive Circuitry

MICRO SWITCH

INTRODUCTION

Linear temperature sensors have a major advantage. The output can be easily conditioned to achieve a desired voltage output span over a particular temperature range. A linear output voltage allows ease of interface to data acquisition systems and programmable controllers. By adjusting the circuit gain, the sensitivity of the output can be adjusted over the total range such as 10° to +40°C.

INTERFACING WITH 1-5V CIRCUIT

If more than 1 mA of current flows through the TD, self-heating will occur. The self-heating effect is typically 0.2°C/milliwatt. The circuits in **Figure 1** and **Figure 2** provide a maximum current flow of 1 mA.

SETTING DESIRED SPAN

The circuit gain depends on the temperature range you want to sense. The offset adjustment is, in turn, dependent on the chosen gain. The transfer function for both circuits (Figures 1 and 2) is as follows:

$(R_5/R_4 + 1) \bullet V[R_{TD}/(R_{TD} + R_7)] - (R_5/R_4)(1 + R_3/R_2)V_1 = v_O$

Only two elements are unknown: the offset (v_1), and the circuit gain ($R_5/R_4 + 1$). To set the desired span, two equations for the two unknowns must be created and solved. To simplify these calculations, the following assumption is made:

$R_5/R_4 = R_2/R_3$

The second assumption is that no self-heating of the TD element will occur: the values of V and R_7 are constant at the values indicated.

$V[R_{TD}/(R_{TD} + R_7)] = 5[R_{TD}/(R_{TD} + 5110)]$

These assumptions reduce the transfer function to:

$(R_5/R_4 + 1) \bullet 5[R_{TD}/(R_{TD} + 5110)] - (R_5/R_4 + 1)v_1 = v_O$

To create the first of the two simultaneous equations, the value of R_{TD} for the desired minimum temperature is taken from **Table 1**. (R_{TD} at 20°C equals 2000 Ohms, and v_O = 1V.) For the second equation, the value of R_{TD} for the desired maximum temperature is taken from the table, and v_O = 5 V.

The two equations are then solved for the gain ($R_5/R_4 + 1$) and the offset (v_1). The following example shows how this is accomplished.

Desired temperature range: 0° to 60°C.
Voltage output over range: 1 to 5 V.

Equation 1: R_{TD} at 0°C is 1854 Ohms.

$(R_5/R_4 + 1) \bullet 5[1854/(1854 + 5110)] - (R_5/R_4 + 1)v_1 = 1\ V$

Equation 2: R_{TD} at 60°C is 2314 Ohms.

$(R_5/R_4 + 1) \bullet 5[2314/(2314 + 5110)] - (R_5/R_4 + 1)v_1 = 5\ V$

Step 1: subtract equation 1 from equation 2.

$(R_5/R_4 + 1)(1.558) - (R_5/R_4 + 1)V_1 = 5$
$(R_5/R_4 + 1)(1.331) - (R_5/R_4 + 1)v_1 = 1$
$(R_5/R_4 + 1)(.227) - 0 = 4$
$(R_5/R_4 + 1) = 4(1/.227)$
$(R_5/R_4 + 1) = 17.62 = \text{GAIN}$

Step 2: substitute ($R_5/R_4 + 1$) = 17.62 into equation 1 and solve for V_1.

$(17.62)(1.331) - (17.62)v_1 = 1$
$23.454 - 17.62v_1 = 1$
$22.452 = 17.62v_1$
$1.274 = v_1 = \text{OFFSET}$

In order to transfer this information into the circuit in **Figure 1**, choose appropriate values for R_4 and R_5 such that:

$(R_5/R_4 + 1) = \text{GAIN}$

For this example, R_4 = 1 K Ohm and R_5 = 16.62 K Ohm would be appropriate.

Choose R_2 and R_3 based on $R_2/R_3 = R_5/R_4$. For this example, choose $R_2 = R_5$ = 16.62 K Ohm, and $R_3 = R_4$ = 1 K Ohm.

To set the offset v_1 using potentiometer R_1, temporarily insert an equivalent discrete resistor in place of the TD element. It should be equal to the TD resistance at the minimum desired temperature (1854 Ohms from the example). Adjust R_1 until the output voltage is 1 V. Replace the discrete resistor with the TD element. The circuit is now set and ready to give 1 V to 5 V output over the chosen temperature range.

Temperature Sensors
Application Data

Figure 1
5.0 V Regulated Circuit

1. LM358 is a general purpose operational amplifier.
2. 2N2222 is a general purpose NPN transistor.
3. Resistor accuracy should be within ±1%.
4. v_O is measured with respect to ground.

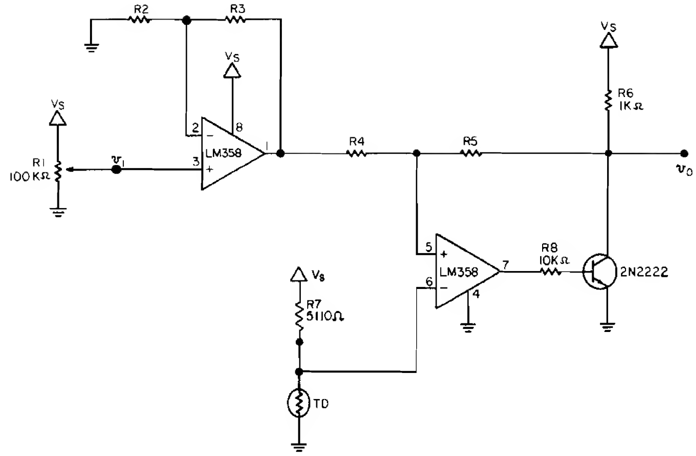


Figure 2
6.5-30 V Supply Voltage

Note: Any error on the 5.0 V regulator will be seen directly on v_O. This error can be reduced when setting the span by assuming that V equals the actual output of the regulator.

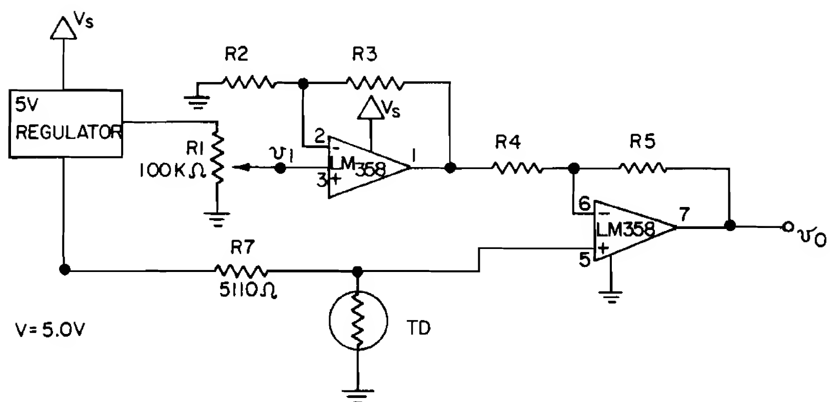
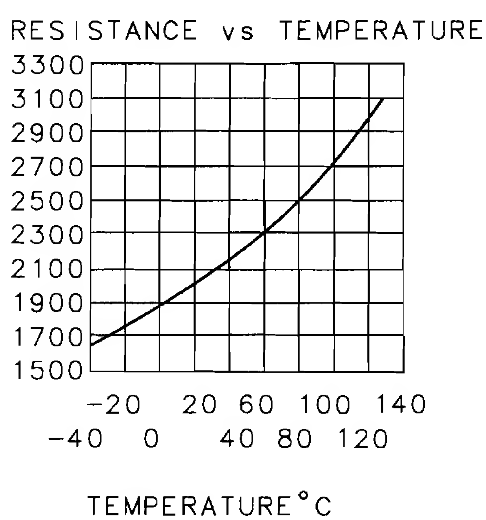


Figure 3
TD Series Resistance vs Temperature



ABSOLUTE MAXIMUM RATINGS	
Operating temperature range	-40 to +150°C (-40 to +302°F)
Storage temperature range	-55 to +170°C (-67 to +338°F)
Voltage	10 VDC Continuous (24 hours)

Linearity
±2% (-25 to 85°C)
±3% (-40 to 150°C)
TD sensors can be linearized to within ±0.2%.

Repeatability
± 1 Ω

ELECTRICAL INTERFACING

The high nominal resistance, positive temperature coefficient and linear sensitivity characteristics of TD Series temperature sensors simplify designing the electrical interface.

Figure 4 is a simple circuit that can be used to linearize the voltage output to within 0.2% or a ±0.4°C error over a range of –40°C to +150°C (–40°F to +302°F).

Figure 5 illustrates an interface for applications requiring a voltage that varies linearly with temperature. In the example shown, the current regulator sensor resistance can be affected by temperature, so only the temperature sensor should be exposed to thermal changes.

In some applications, it may be desirable to detect one particular temperature. Figure 6 illustrates one way this can be accomplished. In the comparator circuit shown, the potentiometer can be adjusted to correspond to the desired temperature.

Figure 4
Linear Output Voltage Circuit

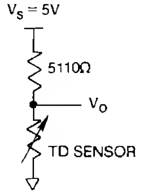


Table 1 – INTERCHANGEABILITY (with 1 μA maximum current)

Temperature	Resistance (Ohms)	Temperature	Resistance (Ohms)
–40°C (–40°F)	1584 ± 12 (1.9°C)	+60°C (140°F)	2314 ± 9 (1.1°C)
-30°C (–22°F)	1649 ± 11 (1.7°C)	+70°C (158°F)	2397 ± 10 (1.2°C)
-20°C (–4°F)	1715 ± 10 (1.5°C)	+80°C (176°F)	2482 ± 12 (1.4°C)
-10°C (14°F)	1784 ± 9 (1.3°C)	+90°C (194°F)	2569 ± 14 (1.6°C)
0°C (32°F)	1854 ± 8 (1.1°C)	+100°C (212°F)	2658 ± 16 (1.8°C)
+10°C (50°F)	1926 ± 6 (0.8°C)	+110°C (230°F)	2748 ± 18 (2.0°C)
+20°C (68°F)	2000 ± 5 (0.7°C)	+120°C (248°F)	2840 ± 19 (2.0°C)
+30°C (86°F)	2076 ± 5 (0.7°C)	+130°C (266°F)	2934 ± 21 (2.2°C)
+40°C (104°F)	2153 ± 6 (0.8°C)	+140°C (284°F)	3030 ± 23 (2.4°C)
+50°C (122°F)	2233 ± 7 (0.9°C)	+150°C (302°F)	3128 ± 25 (2.5°C)

Equation for computing resistance:

$R_T = R_O + (3.84 \times 10^{-3} \times R_O \times T) + (4.94 \times 10^{-6} \times R_O \times T^2)$

R_T = Resistance at temperature T
R_O = Resistance at 0°C
T = Temperature in °C

Figure 5
Simple Current Regulator Interface

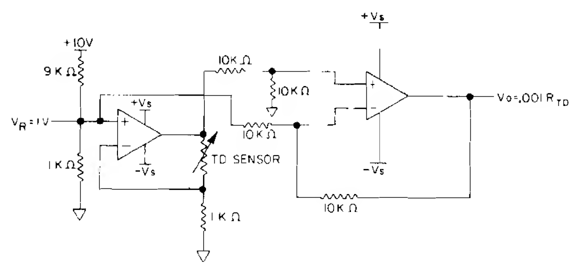
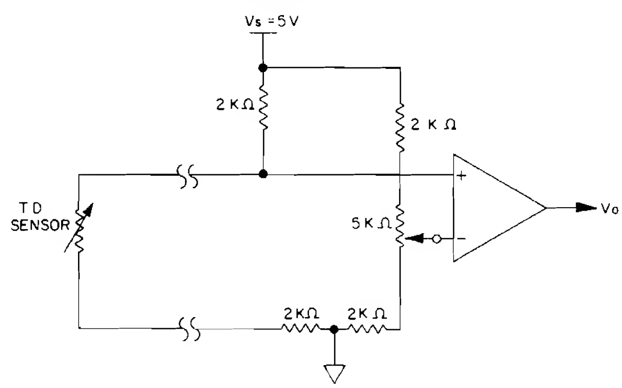


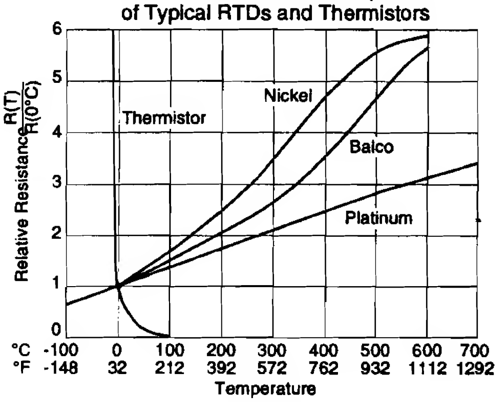
Figure 6
Adjustable Point (Comparator) Interface



PLATINUM RTD RESISTANCE VS. TEMPERATURE FUNCTION

PLATINUM is a precious metal with a very stable and near linear resistance versus temperature function. While intrinsically less sensitive than thermistors or other metals, thin film RTDs provide very high base resistance and high device sensitivity.

Relative Resistance Vs Temperature of Typical RTDs and Thermistors



Platinum's resistance versus temperature function is accurately modeled by the Callendar-Van Dusen equation. This equation uses constants A, B and C, derived from resistance measurements at 0°C, 100°C and 260°C.

Callendar-Van Dusen Equation:

$$R_T = R_0(1+AT+BT^2-100CT^3+CT^4)$$

R_T = Resistance (Ω) at temperature T (°C)
R_0 = Resistance (Ω) at 0°C
T = Temperature in °C

For T>0°C, the quadratic formula can be used to solve for Temperature as a function of measured resistance with the result:

$$0 = R_0BT^2+R_0AT+(R_0-R_T) \text{ implies...}$$

$$T_R = \frac{-R_0A+\sqrt{R_0^2A^2-4R_0B(R_0-R_T)}}{2R_0B}$$

Platinum RTDs are specified by resistance at 0°C, $\mathbf{R_0}$, and alpha, α, a term related to the temperature coefficient of resistance, or TCR. The Callendar-Van Dusen constants A, B and C are derived from alpha α and other constants, delta δ and beta β, which are obtained from actual resistance measurements. Common Callendar-Van Dusen constant values are shown in the table below:

CALLENDAR-VAN DUSEN CONSTANTS†

Alpha, α (°C^{-1})	.003750 ± .00003	.003850 ± .0001
Delta, δ (°C)	1.605 ± 0.009	1.4999 ± 0.007
Beta, β* (°C)	0.16	0.10863
A (°C^{-1})	3.81×10^{-3}	3.908×10^{-3}
B (°C^{-2})	-6.02×10^{-7}	-5.775×10^{-7}
C (°C^{-4})*	-6.0×10^{-12}	-4.183×10^{-12}

*Both β = 0 and C = 0 for T>0°C

The definitions of the Callendar Van Dusen constants: A, B, C, and alpha, delta and beta (α, δ and β), and their inter-relationships are given by the equations below. In all cases, the values of the constants and the fundamental accuracy and repeatability performance of an RTD is determined by the repeatability of the empirically measured resistance values:

$R_0 \pm \Delta R_0 R_{100} \pm \Delta R_{100}$ and $R_{260} \pm \Delta R_{260}$

$$A = \alpha + \frac{\alpha \bullet \delta}{100} \qquad B = \frac{-\alpha \bullet \delta}{100^2} \qquad C_{T<0} = \frac{-\alpha \bullet \beta}{100^4}$$

$$\alpha = \frac{R_{100} - R_0}{100 \bullet R_0} \qquad \delta = \frac{R_0 \bullet (1 + \alpha \bullet 260) - R_{260}}{4.16 \bullet R_0 \bullet \alpha}$$

$$\beta = \text{Constant for } T<0°C$$

TOLERANCE STANDARDS AND ACCURACY

IEC 751, the most commonly used standard for Platinum RTD's defines two performance classes for 100Ω, 0.00385 alpha Pt TRDs, **Class A** and **Class B**. These performance classes (also known as **DIN A** and **DIN B** due to DIN 43760) define tolerances on ice point and temperature accuracy. These tolerances are also often applied to Pt RTDs with ice point resistance outside of IEC 751's 100Ω assumption.

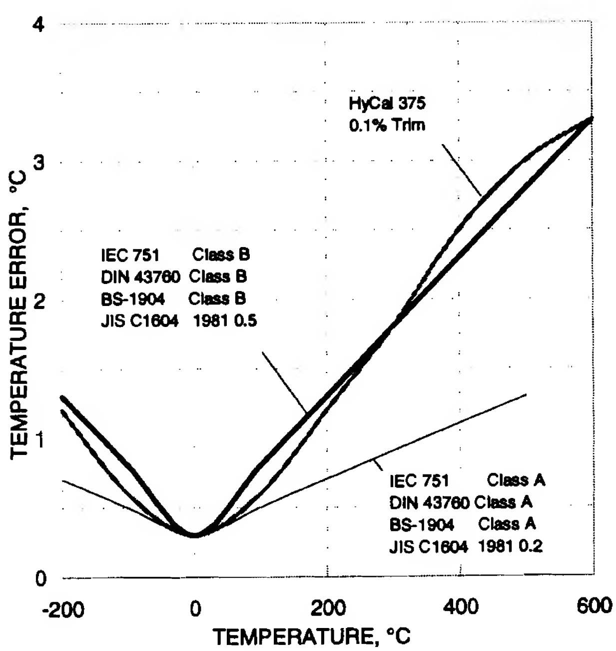
Class C and **Class D** (*each doubling the prior tolerance level*) are also used.

INTERNATIONAL STANDARDS

Standard	Comment	
IEC 751	Defines Class A and B performance for 100Ω 0.00385 alpha Pt RTDs.	
DIN 43760	Matches IEC 751.	
BS-1904	Matches IEC 751.	
JIS C1604	Matches IEC 751. Adds 0.003916 alpha.	
ITS-90	Defines temperature scale and transfer standard.	
Parameter	**IEC 751 Class A**	**IEC 751 Class B**
R_0	100Ω ± 0.06%	100Ω ± 0.12%
Alpha, α	.00385 ± .000063	.00385 ± .000063
Range	−200°C to 650°C	−200°C to 850°C
Res., R_T*	±(.06+.0008|T|−2E-7T²)	±(.12+.0019|T|−6E-7T²)
Temp, T**	±(0.3+0.002|T|)°C	±(0.3+0.005|T|)°C

*Units are Ωs. Values apply to 100Ω Pt RTDs only. Scale by ratio of the R_0s to apply to other ice point resistances.
*Applies to all 0.00385 alpha Pt RTDs independent of ice point, R_0.

PRTD TEMPERATURE ACCURACY



While IEC 751 only addresses 100Ω 385 alpha RTDs, its temperature accuracy requirements are often applied to such other platinum RTDs. However, manufacturers generally present both resistance-vs-temperature accuracies and temperature accuracies in tabular form for direct review.

The Callendar Van Dusen equation analytically addresses the tolerance and accuracy of a Pt RTD at any point within its operating temperature range independent of alpha and ice point resistance. The Resistance Limit-of-Error function (i.e. sensor resistance interchangeability as a function of temperature) can be calculated by taking the differential of the Callendar Van Dusen equation w.r.t. R_0, α and δ and applying the associated uncertainties. While an Expected (RMS) Error function can also be calculated, design engineers are typically interested only in the Limit-of-Error (LOE) function since it characterizes worst case behavior. The LOE function for resistance for T>0°C is:

$$\Delta R_{LOE} = \Delta R_0(1+AT+BT^2) + \Delta A R_0 T + \Delta B R_0 T$$

$$= \Delta R_0 + \Delta\alpha T + (\Delta\alpha\delta + \alpha\Delta\delta)\left[\frac{T}{100} + \frac{T^2}{100^2}\right]$$

Similarly, obtain the Temperature Limit-of-Error (i.e. temperature interchangeability) function using two approaches:

1. Multiply the derivative of R_T by the uncertainty ΔR_T

$$\Delta T_{T_1} = \Delta R_{T_1} \times \left.\frac{\partial R_T}{\partial T}\right|_{T_1}$$

2. Solve the Callendar Van Dusen equation for T, take the differential w.r.t. R_0, α and δ, then apply the appropriate uncertainties. In practice, it is "easier" to take the differential w.r.t. A and B and then apply ΔA and ΔB as calculated from α, $\Delta\alpha$, δ and $\Delta\delta$.

$$\Delta T_{LOE} = \frac{\Delta A}{2B} + \frac{A\Delta B}{2B^2} + \frac{\Delta B\sqrt{R_0^2A^2-4R_0B(R_0-R_T)}}{2R_0^2B^2} + \frac{[R_0^2A^2-4R_0B(R_0-R_T)]^{-\frac{1}{2}}\,[A\Delta A R_0^2+2R_0\Delta B(R_0-R_T)]}{2R_0B}$$

The second relationship could also be calculated in terms of the basic empirical data: $R_0 \pm \Delta R_0$, $R_{100} \pm \Delta R_{100}$ and $R_{260} \pm \Delta R_{260}$.

Temperature Sensors
Application Data

RESISTANCE AND ACCURACY TABLES

PLATINUM RTD RESISTANCE-VS-TEMPERATURE				
Ice Point, Alpha Value & RTD Type	1000Ω 0.00375 Pt Thin Film	100Ω 0.00385 Pt Thin Film	100Ω 0.00385 Pt WW	100Ω 0.003902 Pt WW
Temperature °C	**Resistance (Ω)**			
-200	199.49	18.10	18.10	19.76
-180	284.87	26.81	26.81	28.01
-160	368.57	35.35	35.35	36.17
-140	450.83	43.75	43.75	44.27
-120	531.83	52.04	52.04	52.31
-100	611.76	60.21	60.21	60.31
-80	690.78	68.30	68.30	68.27
-60	769.01	76.32	76.32	76.22
-40	846.58	84.27	84.27	84.15
-20	923.55	92.16	92.16	92.08
0	1000.00	100.00	100.00	100.00
20	1075.96	107.79	107.79	107.92
40	1151.44	115.54	115.54	115.84
60	1226.44	123.24	123.24	123.76
80	1300.96	130.89	130.89	131.69
100	1375.00	138.50	138.50	139.61
120	1448.56	146.06	146.06	147.53
140	1521.63	153.57	153.57	155.45
160	1594.22	161.04	161.04	163.37
180	1666.33	168.46	168.46	171.29
200	1737.96	175.83	175.83	179.21
220	1809.11	183.16	183.16	187.14
240	1879.78	190.43	190.43	195.06
260	1949.96	197.67	197.67	202.98
280	2019.67	204.85	204.85	210.90
300	2088.89	211.99	211.99	218.82
320	2157.63	219.08	219.08	226.74
340	2225.89	226.12	226.12	234.66
360	2293.66	233.12	233.12	242.59
380	2360.96	240.07	240.07	250.51
400	2427.78	246.98	246.98	258.43
420	2494.11	253.83	253.83	266.35
440	2559.96	260.65	260.65	274.27
460	2625.33	267.41	267.41	282.19
480	2690.22	274.13	274.13	290.11
500	2754.63	280.80	280.80	298.04
520	2818.55	287.42	287.42	305.96
540	2881.99	294.00	294.00	313.88
560	2944.96	300.53	300.53	321.80
580	3007.44	307.01		
600	3069.44	313.44		
620	3130.96	319.83		
640	3191.99	326.18		
660	3252.55	332.47		
680	3312.62	338.72		
700	3372.21	344.92		
720	3431.32	351.08		
740	3489.95	357.18		
750	3519.09	360.22		

Sensor accuracy is a function of production tolerance and any additional calibration which the sensor may get. Calibration can improve the accuracy of an RTD by 10X over production tolerance.

The accuracy values in the table below apply to production tolerance tight trim RTDs with ice point tolerances of R_0 ±0.1%. The thin film values are for tight trim platinum RTDs. Both thin film and wire wound tight trim RTDs with 0.00385 alpha values meet IEC 751 Class B.

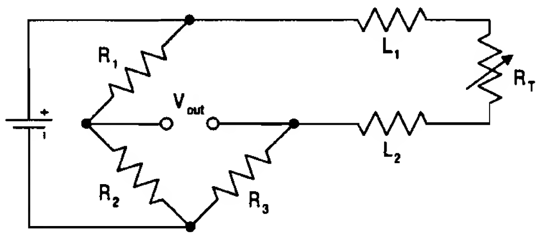
In qualifying volumes, RTDs can be laser trimmed for tight resistance interchangeability at any temperature between 0°C and 150°C or to an ice point resistance other than 100Ω or 1000Ω. Laser trimming also allows matching the resistance of RTD's with different alpha values at a target temperature.

ACCURACY* VS TEMPERATURE			
Ice Point, Alpha Value	1000Ω 0.00375	100Ω 0.00385	100Ω 0.003902
Temperature °C	**±ΔResistance (Ω)**		
-200	5.1	0.5	0.5
-100	2.4	0.3	0.3
0	1.0	0.1	0.1
100	2.2	0.2	0.2
200	4.3	0.4	0.4
300	6.2	0.6	0.6
400	8.3	0.8	0.8
500	9.6	1.0	1.0
600	10.4	1.2	1.2
Temperature °C	**±ΔTemperature (°C)**		
-200	1.2	1.2	1.2
-100	0.6	0.6	0.6
0	0.3	0.3	0.3
100	0.6	0.6	0.6
200	1.2	1.2	1.2
300	1.8	1.8	1.8
400	2.5	2.5	2.5
500	3.0	3.0	3.0
600	3.3	3.6	3.6

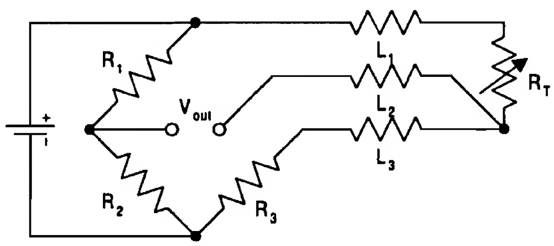
*Figures are for production tolerance tight trim RTDs.

TEMPERATURE CIRCUITS

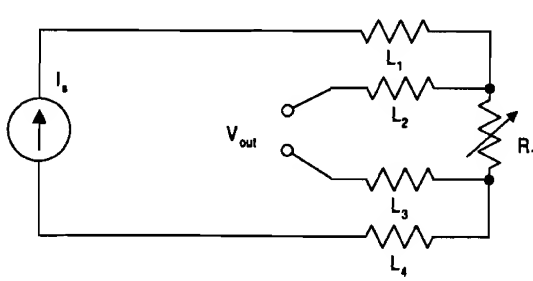
2-WIRE CIRCUIT: A Wheatstone bridge is the most common approach for measuring an RTD. As R_T increases or decreases with temperature, V_{out} also increases or decreases. Use an op-amp to observe V_{out}. Lead wire resistance, L_1 and L_2 directly adds to the RTD leg of the bridge.



3-WIRE CIRCUIT: In this approach, L_1 and L_3 carry the bridge current. When the bridge is in balance, no current flows through L_2 so no L_2 lead resistance is observed. The bridge becomes unbalanced as R_T changes. Use an op-amp to observe V_{out} and prevent current flow in L_2. The effects of L_1 and L_3 cancel when $L_1 = L_3$ since they are in separate arms of the bridge.

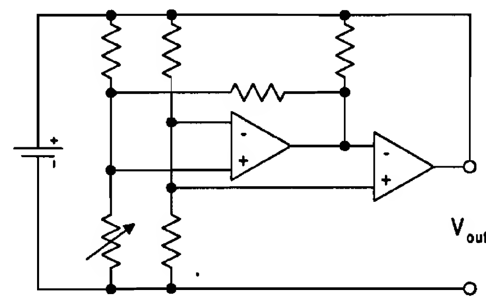


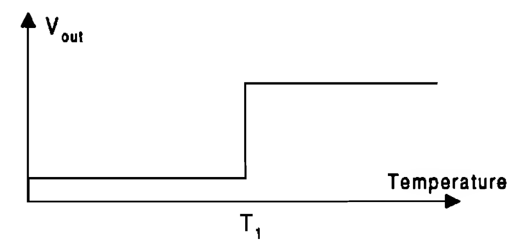
4-WIRE CIRCUIT: A 4-wire approach uses a constant current source to cancel lead wire effects even when $L_1 \neq L_4$. Use an op-amp to observe V_{out} and prevent current flow in L_2 and L_3.



TEMPERATURE SWITCH

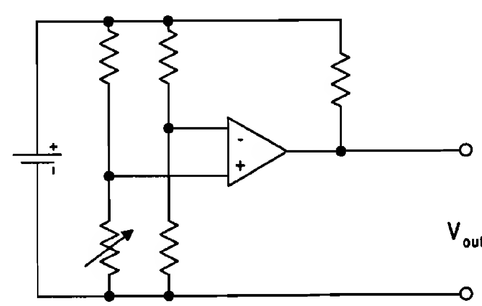
The following circuit causes an output voltage to rail whenever the temperature of the RTD rises above a fixed value T_1. The open-collector output simplifies the interfacing of this circuit with additional electronics.

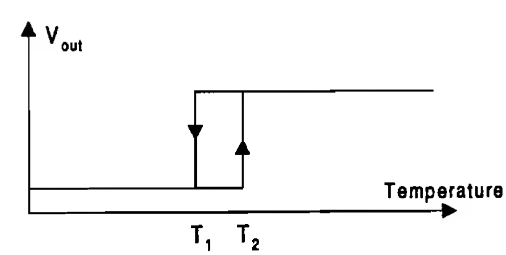




TEMPERATURE SWITCH WITH HYSTERESIS

The following circuit uses positive feedback from the output to self heat the RTD enough to develop a hysteresis in the behavior of the switch. Once on, the temperature must drop low enough to offset the self heating before the switch will disable.





HOT FILM ANEMOMETRY

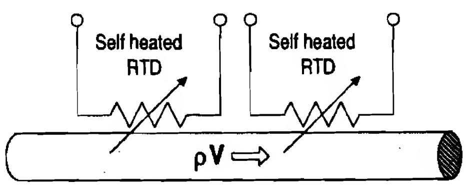
ANEMOMETRY balances heat gains with flow induced heat losses. Anemometers are constructed so that the dominant thermal loss for one or more heated RTDs is convective heat transfer to material flowing past the sensor.

Thermal Energy Gain = Σ Thermal Energy Losses

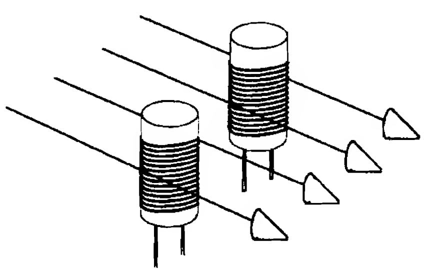
$$= \begin{bmatrix}\text{Radiative}\\ \text{Loss}\end{bmatrix} + \begin{bmatrix}\text{Conductive}\\ \text{Loss}\end{bmatrix} + \begin{bmatrix}\text{Convective}\\ \text{Loss}\end{bmatrix}$$

$$+ \begin{bmatrix}\text{Conductive}\\ \text{Loss to Flow}\end{bmatrix} \approx \begin{bmatrix}\text{Conductive}\\ \text{Loss to Flow}\end{bmatrix}$$

Capillary-Tube flow designs examine the differences in two self heated RTDs held at either equal temperature or equal electronic power input. Flowing material causes either a smaller thermal loss or a higher temperature at the down stream heater.

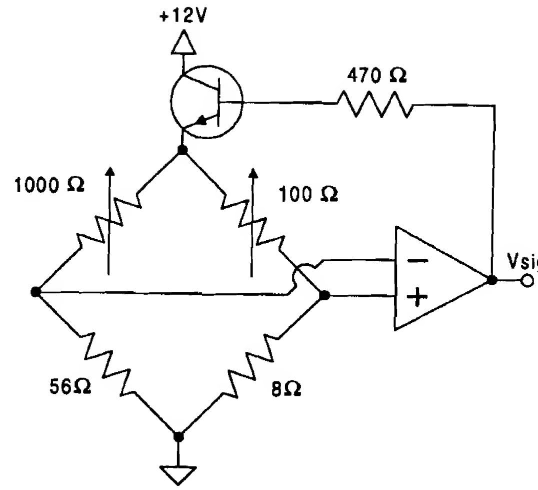


Immersion flow designs commonly use a self heated RTD and temperature compensation RTD with $T_{heated} = T_{amb} + \Delta T$, ΔT = constant. The velocity of the flowing material is then related to the heating energy, I^2R, required to keep ΔT = constant.



A common self heating immersion circuit uses two RTDs with very different ice point values in a bridge configuration. Current self heats the smaller RTD, $T = T_{amb} + \Delta T$, until its simultaneous increase in resistance, $R = R(T_{amb} + A\,\Delta T$, balances the bridge.

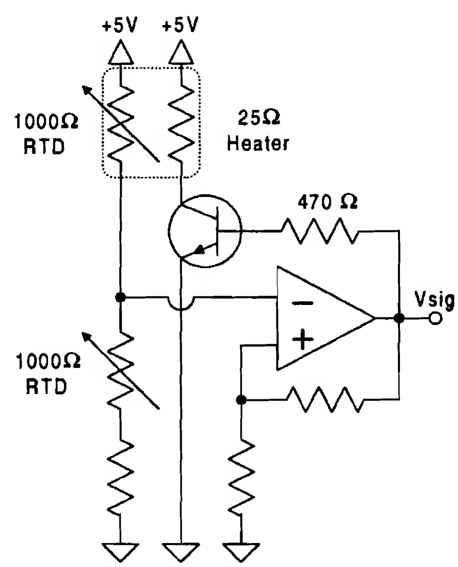
The large RTD provides temperature compensation. As T_{amb} increases, the large RTD's resistance increase causes further heating of the small RTD so that ΔT is held constant. The large difference in RTD ice point values insures that the large RTD does not self heat since most of the power is directed into the smaller RTD.



Temperature compensation allows calibration of flow velocity against V_{sig} (generally nonlinear) independent of the flow temperature, T_{amb}. If the temperature compensation is not good enough, i.e. $\Delta T = f(T_{amb})$, calibrate versus velocity and flow temperature. For optimal temperature compensation, matched sensitivities (over the T_{amb} range) are required, specifically:

$$\left.\frac{\partial R_{self\ heated}}{\partial T}\right|_{(T_{amb}+\Delta T)} = \left.\frac{\partial R_{temp\ comp}}{\partial T}\right|_{T_{amb}} \quad \text{For all } T_{amb}$$

If high heating power is required (such as in a liquid) use two RTDs and a separate heater. A separate heater also improves temperature compensation since identical RTDs with matched alphas can be used. However, the best ambient temperature compensation requires that the sensitivities rather than alpha values be matched.



HEAT CONDUCTION EQUATION AND RTD SELF HEATING

HEAT FLOW: Time response and other heat flow phenomena are governed by the Heat Conduction Equation. Solutions to the Heat Conduction Equation consist of a time independent final temperature distribution and a series sum of exponentially damped orthogonal functions which describe the evolution of the temperature distribution from the initial condition $f(x)$ to the final condition[1]. (Do not confuse the alpha used in this equation with the alpha used to describe an RTD's R-T curve.)

Heat Conduction Equation: $\alpha^2 \nabla^2 u = \dfrac{\partial u}{\partial t}$

$\alpha^2 = \dfrac{\kappa}{\rho s}$ Thermal Diffusivity (m^2/s)

$\kappa =$ Thermal Conductivity (J/s • m • °C)

$\rho =$ Density (kg/m^3)

$s =$ Specific Heat (J/°C)

Apply the Heat Conduction Equation to a thin film RTD mounted to a very thermally conductive, i.e. metal, surface, figure 1 below. Since the RTD is very thin, approximate the problem as one-dimensional in x with a general solution $u(x, t)$ as shown below:

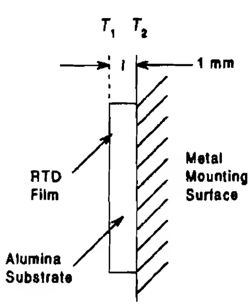


Figure 1

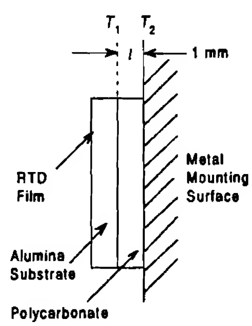


Figure 2

$$u(x,t) = (T_2 - T_1)\frac{x}{l} + T_1 + \sum_{n=1}^{\infty} b_n e^{-n^2\pi^2\alpha^2 t/l^2} \sin\left[\frac{n\pi x}{l}\right]$$

$$b_n = \frac{2}{l}\int_0^l \left[f(x) - (T_2 - T_1)\frac{x}{l} - T_1\right] \sin\left[\frac{n\pi x}{l}\right]$$

$f(x) =$ Temperature distribution at time $t = 0$.

SELF HEATING: Once heat is introduced into the RTD by resistive heating, the equation which defines thermal conductivity must be satisfied:

$$j_u = -\kappa \frac{\partial u(T)}{\partial x}$$

Applying the conductivity equation as a boundary condition on the general solution for the RTD-on-a-surface example, $u(x, t)$ results in the self heating relationship:

$$\frac{P}{A} = -\alpha^2 u'(0)$$

$P =$ Thermal power dissipated in the RTD $= V_T^2/R(T)$

$A =$ Surface area of the RTD

Yielding our result:

$$\frac{P}{A} = -\alpha^2 \frac{(T_2 - T_1)}{l} \text{ or } T_1 = \frac{lP}{\alpha^2 A} + T_2 = \frac{lV_T^2}{\alpha^2 A\, R(T)} + T_2$$

Example 1: Applying the result to a low thermal impedance situation, examine an HEL-700 at 0°C, with 0.254 mm (0.010 in) thick alumina substrate (diffusivity k = 38 W/m°C) and 1000 Ω ice point resistance. Here the self heating error calculated from a 2.3 mA current is negligible, less than 0.02°C.

Example 2: Examining a high thermal impedance situation, use the same RTD, encapsulated in a plastic or epoxy package such as a TO-92. Approximating this as an intervening 1 mm thick layer of polycarbonate with diffusivity of 0.199 W/m°C, the 2.3 mA current now generates a 12.4°C offset.

A plastic encapsulated RTD will exhibit significantly greater temperature offset error than the same un-encapsulated RTD when both are mounted to a surface (or environment) with good thermal conductivity. However, for air measurement, the opposite occurs as the table illustrates!

TEMPERATURE OFFSET IN STILL AIR

RTD Current	Ceramic SIP	Encapsulated
0.1 mA	<0.02°C	<0.02°C
1.0 mA	0.83°C	0.50°C

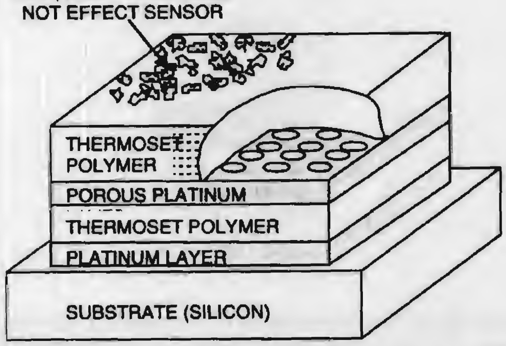
Conclusion: When the thermal conductivity of the sensor packaging is lower than the thermal conductivity of the environment being measured, then the sensor packaging can increase self heating. More importantly, lower operating currents always reduce or eliminate self heating errors.

[1] Note that the constant α used in the Heat Conduction equation is different from the alpha used to describe a platinum RTD.

HUMIDITY SENSOR THEORY AND BEHAVIOR

SENSOR CONSTRUCTION: Relative humidity sensors use an industrially proven thermoset polymer, three layer capacitance construction, platinum electrodes and except for high temperature versions (shown bottom), on-chip silicon integrated voltage output signal conditioning. (RHIC Sensor).

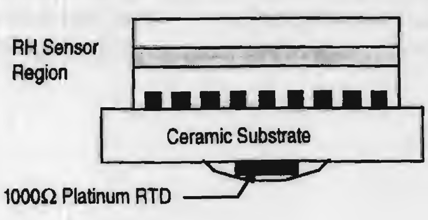
In operation, water vapor in the active capacitor's dielectric layer equilibrates with the surrounding gas. The porous platinum layer shields the dielectric response from external influences while the protective polymer over layer provides mechanical protection for the platinum layer from contaminants such as dirt, dust and oils. A heavy contaminant layer of dirt will slow down the sensor's response time because it will take longer for water vapor to equilibrate in the sensor.



TEMPERATURE & HUMIDITY EFFECTS: The output of all absorption based humidity sensors (capacitive, bulk resistive, conductive film, etc.) are affected by both temperature and %RH. Because of this, temperature compensation is used in applications which call for either higher accuracy or wider operating temperature ranges.

When temperature compensating a humidity sensor, it is best to make the temperature measurement as close as possible to the humidity sensor's active area, i.e. within the same moisture micro-environment. This is especially true when combining RH and temperature as a method for measuring dew point.

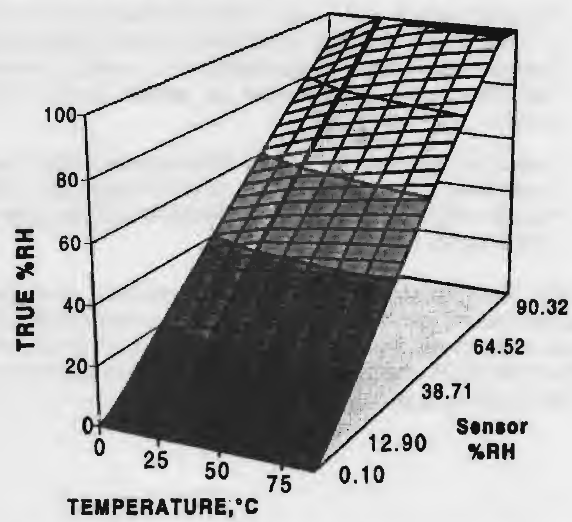
Industrial grade Humidity and Dew Point instruments incorporate a 1000 ohm Platinum RTD on the back of the ceramic sensor substrate for unmatched temperature compensation measurement integrity. No on-chip signal conditioning is provided in these high temperature sensors.



VOLTAGE OUTPUT: The RHIC sensor linear voltage output is a function of V_{supply}, %RH and temperature. The output is "ratiometric," i.e. as the supply voltage rises, the output voltage rises in the same proportion. A surface plot of the sensor behavior for temperatures between 0°C and 85°C is shown in the graph below. This surface plot is well approximated by a combination of two equations:

1. A "Best Fit Line at 25°C," or a similar, sensor specific equation at 25°C. The sensor independent "typical" Best Fit Line at 25°C (bold line in graph) is:
   $V_{out} = V_{supply}$ (0.0062 (%RH) + 0.16)
   A sensor specific equation can be obtained from an RH sensor printout. The printout equation assumes V_{supply} = 5VDC and is included or available as an option on every sensor.

2. A sensor independent equation which corrects the %RH reading (from the Best Fit Line Equation) for temperature, T:
   True RH = (%RH)/(1.0546–.00216 T); T = °C
   Or True RH = (%RH)/(1.093–.0012 T); T = °F



The equations above match the typical surface plot (Best Fit Line at 25°C) or the actual surface plot (sensor specific equation at 25°C) to within the following tolerances:

±1% for T>20°C
±2% for 10°C<T<20°C
±5% for T<10°C

Our dewpoint instruments account for the sensor specific version of the surface plot directly via a look up table.

NOTE: Convert the observed output voltage to %RH values via the first equation before applying the second equation.

CONDENSATION AND WETTING

CONDENSATION occurs whenever the surface temperature of the sensor's active area drops below the ambient dew point of the surrounding gas. Condensation forms on the sensor (or any surface) even if the surface temperature only momentarily drops below the ambient dew point. Small temperature fluctuations near the sensor can unknowingly cause condensation to form when operating at humidity levels above 95%.

While quick to condense, water is slow to evaporate in high humidity conditions (i.e. when the surface temperature of the sensor is only slightly above the ambient dew point.) Because of this, a sensor's recovery period from either condensation or wetting is much longer than its normal time response. During recovery, the sensor outputs a constant 100% RH signal regardless of the ambient RH.

When an application calls for continuous monitoring of RH at humidity levels of 90% and above, take steps to avoid intermittent condensation. Some strategies are:

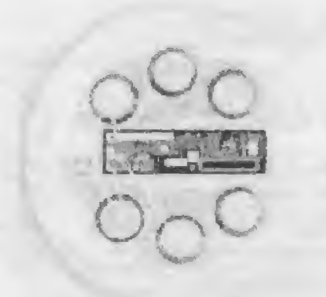
1. Maintain a good air mixing to minimize local temperature fluctuations.
2. The HIH-3602-A and -C use a sintered stainless steel filter to protect the sensor from splashing. A hydrophobic coating further suppresses condensation and wetting in rapidly saturating and de-saturating or splash prone environments.
3. Heat the RH sensor so that the active area is hotter than the local dew point. This can be done through an external heater or by self heating of the CMOS RH chip by operating it at a higher supply voltage.

NOTE: Heating an RH sensor above ambient temperature changes its calibration and makes it sensitive to thermal disturbances such as air flow. When contemplating such an approach, MICRO SWITCH recommends selecting an HIH-3602 type sensor and getting application technical support.

INTEGRATED SIGNAL CONDITIONING

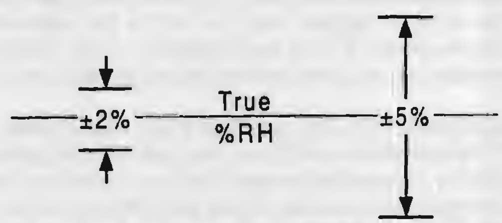
All RH sensors quickly recover from condensation or wetting with no shift in calibration. However, after 24 hour or longer exposures to either high >95% RH or continuous condensation, an upward shift of 2% to 3% RH may occur. This shift is repeatable and can be reversed by placing the sensor in a low 10% RH environment for a 10 hour period.

Silicon integrated humidity sensors (RHIC – relative humidity integrated circuit) incorporate signal conditioning circuitry on-chip with the sensing capacitor. These "RHIC" humidity sensors are laser trimmed so that at V_{supply} = 5 V, the output voltage typically spans 0.8V to 3.9V for the 0% RH to 100% RH range at 25°C. (Sensor specific calibration data printouts and best fit lines at 25°C are either included or available as an option on every sensor.)



The HIH-3602-C incorporates a RHIC humidity sensor, a 1000Ω platinum RTD and anti-static protection in a single TO-5 can.

RHIC based sensors are factory calibrated, micro-power devices with either individual calibration and/or good unit-to-unit interchangeability. These features help OEM manufacturers avoid in-house humidity calibration costs and extend battery life in portable instruments. Improved accuracy can be obtained by tuning system electronics to account an individual sensors Best Fit Line at 25°C.



System performance when accounting for the sensor specific data.

System performance when relying on sensor interchangeability.

HUMIDITY SENSOR CHEMICAL RESISTIVITY

Humidity sensors are routinely exposed to chemically active environments in the process of making moisture measurements. Chemical resistivity is an important differentiate between competing sensors and resulting system accuracy and reliability. To address this, MICRO SWITCH always uses proprietary, chemically resistive and thermally stable thermoset polymer as the active medium in all of its humidity and moisture sensors.

While following data reflects testing on the HIH-3602 sensor, the results are indicative of all other MICRO SWITCH moisture sensors. Protocols are severe relative to typical applications.

SATURATION AND RECOVERY PROTOCOL

- For each chemical tested, seven HIH-3602 sensors calibrated at 0% and 75.3% RH.
- A chemical saturation test was done by placing a drop of chemical on top of the sensor completely covering the hydrophobic filter for 175 minutes. A blow dryer was then applied to reduce the RH reading from 100% back down to room ambient.
- The sensors were again tested at 0% and 75.3% RH.
- The sensors are next allowed to recover under ambient RH for 60 hours.
- The sensors are again tested at 0% and 75.3% RH.

SATURATION & RECOVERY RESULTS

	Post Saturation		**Post Recovery**	
Chemical	Δ% at 0% RH	Δ% at 75.3% RH	Δ% at 0% RH	Δ% at 75.3% RH
Alcohol Isopropyl, 66%	+0.1	+1.13	+0.0	+1.83
Endo-Spor Hydrogen Peroxide	+0.46	−0.16	+0.4	−0.43
Glutaraldehyde Cydex Plus	+0.56	−2.13	+0.63	−1.63
Idophors Solution Westcodyne	+0.23	+0.16	+0.36	+0.93
Kleenaseptic	+3.13	+4.5	+2.96	+4.66
Quaternary Ammonium Virex 0.2%	+0.43	+0.2	+0.3	+0.8
Sodium Hypochlorite	+0.36	+0.6	+0.43	+1.53

LONG TERM VAPOR EXPOSURE PROTOCOL

- For each chemical tested, three HIH-3602 sensors were suspended 0.75 inches above the liquid chemical surface in a hermetically closed flask.
- Periodically, sensors were removed and tested at 0% RH and 75.3% RH.

Note that an entry of "F" denotes sensor failure. Blank entries indicate that the data was not taken.

LONG TERM EXPOSURE RESULTS

	Δ% RH Change over Exposure Time							
Chemical	89.0 hr		231.5 hr		400.0 hr		893.0 hr	
	0%	100%	0%	100%	0%	100%	0%	100%
Ammonia Hydroxide	F	F	F	F	F	F	F	F
Acetone	F*	F	F	F	F	F	F	F
Ethanol	F	F	F	F	F	F	F	F
Methanol	−1.9	25.1	−1.9	29.4	−3.7	35.0	−5.4	39.8
50% Ethanol + 50% Methanol	14.5	−17.4			7.8	−31.8	4.2	−22.0
Formaldehyde hyst. grade	0.8	0.0	1.5	−0.3	1.5	−1.4	1.9	−3.5
Formaldehyde neutral soln.	0.6	−0.7	1.2	−2.0	1.1	−3.5	1.6	−6.1
Formaldehyde norm & buff'd	0.4	0.8	1.2	−0.4	1.1	−1.3	1.5	−3.2
Benzene	−2.0	1.5	−1.1	−1.7	−0.3	−8.1	−1.1	−24.7
Toluene	−1.7	1.4	−0.8	0.4	0.4	0.0	−0.9	−4.3
Xylene	−1.7	1.5	−0.8	−0.2	−0.6	−0.7	−0.9**	0.0²
30% Benzene + 30% Toluene + 40% Xylene	−03	−1.2			−0.1	−6.0	−0.6	−16.1

*Sensors are resistant to acetone over shorter exposures.
**One sensor failed.

PSYCHROMETRICS & MOISTURE

MOISTURE measurements involve different terms and units. Moisture terms and units all fall under the area of psychrometrics, the study of water vapor concentration in air as a function of temperature and pressure. Selecting a moisture term depends on the application at hand.

Dew points and frost points are often used when the dryness of the gas is important, (moisture condensation from gas at low process temperatures must be avoided). Dew point is also used as an indicator of water vapor in high temperature processes, such as industrial drying.

Mixing ratios, volume percent, and specific humidity are usually used when water vapor is either an impurity or a defined component of a process gas mixture used in manufacturing. Mixing ratios are also used, like dew point, in industrial drying.

Relative humidity is most commonly used in HVAC applications where it directly impacts human comfort and indoor air quality issues. Relative humidity is also of interest to process control personnel as low RH can cause brittleness and static electricity problems, while high RH can cause swelling and clumping regardless of temperature.

MOISTURE TERMS, DEFINITIONS AND UNITS

Term	Definition	Unit
Absolute Humidity, (Vapor concentration)	$\frac{\text{Mass, Vapor}}{\text{Volume}}$	Grains/ft^3 Grams/m^3
Mixing Ratio	$\frac{\text{Mass, Vapor}}{\text{Mass, dry gas}}$	lb/lb, grains/lb, kg/kg, grams/kg
Relative Humidity	$\frac{\text{Mass, actual vapor}}{\text{Mass saturated vapor}}$ $\frac{\text{Actual vapor pressure}}{\text{Saturation vapor pressure}}$ $\frac{\text{Partial pressure, vapor}}{\text{Vapor pressure water}}$	%
Dew Point	Temperature of saturation (condensation)	°F or °C
Volume Ratio	$\frac{\text{Partial pressure, vapor}}{\text{Partial pressure, dry gas}}$	% by volume
Mass Ratio	Same as Mixing Ratio	PPM by weight, PPM_w
PPM by volume	$\frac{\text{Volume, vapor x }10^6}{\text{Volume, dry gas}}$	PPM by volume, PPM_v
PPM by weight	$PPM_v \times \frac{\text{Mole weight of water}}{\text{Mole weight of carrier gas}}$	PPM by weight, PPM_w
Hygrometer	Instrument for measuring moisture in gas (from Greek hygros – wet, moist)	
Psychrometer	Instrument using wet/dry bulbs to measure moisture in gas (from Greek psychros – cold)	

PSYCHROMETRICS deals with the thermodynamic properties of moist gases while the term **Humidity** simply refers to the presence of water vapor in air or other carrier gas.

Psychrometrics concerns mixtures of water vapor and dry air. Much of it also applies to other carrier gases since the thermodynamic characteristics of water vapor are fairly independent of the carrier gas. In addition, as the composition of atmospheric air is fairly constant, dry air is treated as a homogeneous gas with a molecular weight of 28.9645. The molecular weight of water is 18.01528.

PARTIAL PRESSURE: The gas laws say that the total pressure of a gas mixture is the sum of the partial pressures of the constituent gases. Also the volume ratios of constituent gases are equal to the ratios of their partial pressures. For example, atmospheric pressure is the sum of the partial pressures of dry air and water vapor ($\rho_{atm} = \rho = \rho_a + \rho_w$).

WATER VAPOR PRESSURE: When a mixture of air and water vapor is in equilibrium with liquid water or with ice, it is considered to be saturated (RH = 100%). The water vapor saturation pressure over ice for the temperature range of −148 to 32°F is given by:

$$\ln(\rho_{ws}) = \frac{C_1}{T} + C_2 + C_3T + C_4T^2 + C_5T^3 + C_6T^4 + C_7\ln(T)$$

where $C_1 = -1.0214165E+04$, $C_2 = -4.8932428E+00$, $C_3 = -5.3765794E-03$, $C_4 = 1.9202377E-07$, $C_5 = 3.5575832E-10$, $C_6 = -9.0344688E-14$, $C_7 = 4.1635019E+00$

The saturation pressure over *liquid water* for the temperature range of 32 to 392°F is given by:

$$\ln(\rho_{ws}) = \frac{C_8}{T} + C_9 + C_{10}T + C_{11}T^2 + C_{12}T^3 + C_{13}\ln(T)$$

where $C_8 = -1.0440397E+04$, $C_9 = -1.1294650E+01$, $C_{10} = -2.7022355E-02$, $C_{11} = 1.2890360E-05$, $C_{12} = -2.4780681E-09$, $C_{13} = 6.5459673$

In both of the above equations,

ρ_{ws} = saturation pressure, psia
T = absolute temperature, °R = °F + 459.67

SIMPLIFIED FORMULATIONS: The preceding equations are very accurate, but may be overly cumbersome for real time calculation. The following equations are less accurate, but are generally suitable for mid-range calculations as used in HVAC applications, for example.

For dew points higher than ice point:

$$e = [1.0007+P\times3.46E-6] \times 6.1121 \times \exp\left[\frac{17.502 \times T}{240.9 + T}\right]$$

For dew points at or below ice point:

$$e = [1.0003+P\times4.18E-6] \times 6.1115 \times \exp\left[\frac{22.452 \times T}{272.55 + T}\right]$$

e » p_w vapor pressure in millibars (one psi = 68.94745 millibars)

P = total pressure in millibars (1 atm = 1013.25 millibars, 14.696 psia)

T = temperature in °C(°F=°C×1.8+32)

RELATIVE HUMIDITY: the ratio of the partial vapor pressure to saturation vapor pressure at the dry bulb temperature:

$$RH = \frac{\rho_W}{\rho_{WS}} = \frac{\rho_{WS}(T_d)}{\rho_{WS}(T)}$$

where $\rho_{WS}(T_d)$ is saturation pressure at the dew point temperature and $\rho_{WS}(T)$ is saturation pressure at the dry bulb temperature. Relative humidity is moisture and temperature dependent but independent of total pressure. If dew point and dry bulb temperatures are known, then RH can be derived by calculating saturation vapor pressure for dew point and for dry bulb, then applying the RH definition above.

DEW POINT is the temperature at which a given sample of moist air is saturated. If the sample is cooled below dew point, then water vapor begins to condense. This phenomenon is the basis for various chilled sensor type dew point meters.

Frost Point: If measurements are made below the freezing point of water – that is if the indicated dew point is below the freezing point of water, then the equilibrium occurs at the vapor pressure of ice (not water), which is less than that of water. That is, the frost point is a bit higher than dew point.

If RH and dry bulb temperature are known, dew point can be derived by first calculating saturation pressure at the dry bulb temperature and then multiplying by the RH ratio to obtain ρ_w, the partial water vapor pressure. Now apply the following:

For the dew points in the range of 32 to 200°F:

$$T_d = C_{14} + C_{15}\alpha + C_{16}\alpha^2 + C_{17}\alpha^3 + C_{18}\rho_W^{0.1984}$$

And for dew points below 32°F:

$$T_d = 90.12 + 26.412\alpha + 0.8927\alpha^2$$

Where for both expressions:

T_d = dew point, °F	$\alpha = \ln(\rho_W)$, ρ_W in psia
C_{14} = 100.45	C_{15} = 33.193
C_{16} = 2.319	C_{17} = 0.17074
C_{18} = 1.2063	

VOLUME RATIO (also called mixing ratio by volume, or ppmv) is the ratio of water vapor volume to dry air volume (V_w/V_a). Because the volume ratios of mixed gases are the same as their partial pressures, volume ratio can be expressed as:

$$VR = \frac{\rho_W}{\rho_a};\ \rho = \rho_W + \rho_a$$

Because total pressure is the sum of partial pressures, the partial pressure of dry air can be readily derived (once vapor pressure is known), by measuring total pressure directly or by assuming one atmosphere (14.696 psia) total pressure. Multiply the ratio by one million to obtain ppmv (parts per million by volume).

HUMIDITY RATIO (also called mixing ratio by weight, or ppmw) is the ratio of the mass of water vapor to the mass of dry air. To calculate this, multiply the volume ratio by the ratio of the molecular weights:

$$W \equiv \frac{M_W}{M_a} = \frac{18.01528\ \rho_W}{28.9645\ \rho_a} = 0.62198\ \frac{\rho_W}{\rho_a}$$

The humidity ratio, in common use, is expressed in lb/lb, grains/lb, kg/kg, or g/kg. (There are 7000 grains in one pound.) Multiply the ratio by one million to obtain ppmw (parts per million by weight). An engineer may, for example, combine a humidity ratio value with the reading from a mass flow meter to calculate the mass of water vapor flowing through a dryer exhaust duct per unit time.

VOLUME PERCENT: equivalent to 100 times the mole fraction; the ratio of water vapor volume to total volume, V_w/V or $V_w/(V_w + V_a)$ expressed as a percentage. Like the volume ratio, it can be calculated in terms of partial pressures:

$$V\% = \frac{\rho_W}{\rho};\ \rho = \rho_W + \rho_a$$

SPECIFIC HUMIDITY: normally expressed as a percentage, is the ratio of the mass of water vapor to the total mass, and can also be calculated in terms of the humidity ratio:

$$q = \frac{M_W}{M_W + M_a} = \frac{W}{1 + W}$$

ABSOLUTE HUMIDITY: (or water vapor density) is the ratio of the mass of water vapor to the total volume:

$$d_v = \frac{M_v}{V} = \frac{217.6 \times e}{T_{cb} + 273.16}$$

d_v = absolute humidity expressed in grams H_2O per cubic meter of dry air and vapor mix (divide by 16,018.46 for lb/cu ft; divide by 2.28835 for grains/cu ft)

e = ρ_W vapor pressure in millibars (1 psi = 68.94745 millibars)

T_{cb} = dry bulb temperature in °C (°F = °C × 1.8 + 32)

ENTHALPY: the measure of the energy content per unit mass. The enthalpy of a gas mixture equals the sum of the individual partial enthalpies of the components, (dry air and water vapor). In the English system, the specific enthalpy of dry air is assigned a value of zero at 0°F and standard atmospheric pressure. To calculate moist air enthalpy in Btu/lb dry air:

$$h = 0.240T + W(1061 + 0.444T)$$

where
T = dry bulb temperature, °F
W = humidity ratio of the moist air

STANDARD ATMOSPHERIC DATA: Normal atmospheric pressure variations have small effects on calculations that require a value for total pressure. However, at higher altitudes (Denver, for example), atmospheric pressure variations become significant. The following standard data is adapted from NASA. At sea level, standard temperature is 59°F and standard barometric pressure is 29.921 in. Hg.

STANDARD ATMOSPHERIC PRESSURE DATA

Altitude	Temp.	Pressure	
ft	°F	in Hg.	psia
0	59.0	29.921	14.696
500	57.2	29.38	14.430
1000	55.4	28.86	14.175
2000	51.9	27.82	13.664
3000	48.3	26.82	13.173
4000	44.7	25.82	12.682
5000	41.2	24.90	12.230

Reference: 1993 ASHRAE Handbook of Fundamentals, published by American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329. Telephone 404-636-8400.

NOTE: Most of the ASHRAE formulations are based on the thermodynamic temperature scale, which differs very slightly from practical scales (ITS-90) used for physical measurements. The boiling point of water is 211.95°F on this scale rather than the traditional 212°F. The slight difference is negligible for any practical application.

SATURATION VAPOR PRESSURES OF WATER P_w

Temperature (°C)	Saturation Vapor Pressure (mmHg)	Temperature (°C)	Saturation Vapor Pressure (mmHg)
-20	0.8	60	149.5
-10	1.9	70	233.8
0	4.6		
10	9.2		
20	17.5		
30	31.8	80	355.3
40	55.4	90	525.9
50	92.6	100	760.0

Solid State Sensors
Glossary of Terms

Absolute Maximum Ratings

Supply Voltage: Range of voltage which may be applied to the positive terminal of a sensor without damage.

Voltage Externally Applied to Output: Refers to the breakdown voltage of the output transistor between the collector and emitter when transistor is OFF. Voltage measured at the output terminals of an inactivated sensor must never exceed 30 VDC, or sensor may be damaged.

Output Current: Maximum output current which may flow through an actuated sensor without damaging the sensor.

Temperature: Range over which the sensor will operate without damage. This is **not** the actual rated temperature range over which the sensor will meet the specified operational characteristics.

Magnetic Flux: Hall effect sensors cannot be damaged by excessively large magnetic field density.

Bipolar sensor, magnetic — A Hall effect sensor that has a plus (South pole) maximum operate point, and a minus (North pole) minimum release point. Operate and release points can also be both positive or both negative. Therefore, **latching cannot be guaranteed.** Ring magnets are usually used with bipolar sensors.

Bipolar-latching sensor, magnetic — A true latching device. Guaranteed to switch on with positive gauss only and switch off with negative gauss only.

Capillary Tube Flow Design — Examines differences in two self-heated RTDs held at equal temperature or equal input.

Current sinking output (NPN) — Load is connected between power supply and sensor. Current flows from the load through the sensor to ground (open collector).

Current sourcing output (PNP) — Load is connected between sensor and ground. Current flows from the sensor through the load to ground (open emitter).

Dew Point — Point at which a given sample of air is saturated. Related standards of measurement include Frost Point, and Ice Point.

Differential travel (D.T.) — Plunger or actuator travel from point where contacts "snap-over" to point where they "snap-back."

Enthalpy — A thermodynamic function of a system, equivalent to the sum of the internal energy of the system plus the product of its volume multiplied by the pressure exerted on it by its surroundings.

Flux concentrator — Any ferrous material positioned so as to concentrate magnetic flux in the sensing area, thereby increasing the flux density as seen by the Hall effect sensor.

Frost Point — If measurements are made below freezing point of water (if indicated dew point is below freezing point of water), then equilibrium occurs at vapor pressure of ice (not water). Vapor pressure of ice is less than that of water. The frost point is slightly higher than dew point. Often used when dryness of the gas is an important determination.

Gauss — The CGS unit of flux density (magnetic induction).

Hall effect — The description given to the following phenomena: When a conductor through which a current is flowing is placed in a magnetic field, a difference in potential (Hall voltage) is generated between the two opposed edges of the conductor in the direction perpendicular to both the field and the current.

Hysteresis — The property of a digital Hall effect sensor where its operate point is different in value from its release point.

IAQ — Indoor Air Quality: calculated using CO_2 levels found in indoor air; high levels of CO_2 create an awareness of volatile organic compounds (VOCs) and bacteria.

Ice Point — Equal to 0°C (32°F), is the temperature at which pure water at 1 atm of pressure freezes. It is the physical phenomenon upon which the centigrade temperature scale was originally based:

0°C = pure water, at 1 atm pressure, freezes

100°C = pure water, at 1 atm pressure, boils.

Linearity — The closeness of an actual curve to a specified straightline. The degree to which the output of a linear device deviates from ideal performance.

Linear output — An output which changes in proportion to the input.

Magnetoresistive effect — The change in the resistance of a semiconductor device in which the electrical resistance is a function of the applied magnetic field. A magnetoresistive element will respond to any magnetic fields (North **or** South pole) which are **parallel** to it.

Moisture Measurements — Mix of ratios, volume percent, and specific humidity – used when water vapor is an impurity or a defined component of a process gas mixture used in manufacturing.

North pole (magnetic) — The pole that is attracted to the geographical north pole, therby repelling the north seeking pole of a compass. Lines of flux are directed away from this pole.

Omnipolar sensor, magnetic - A sensor that operates with any magnetic field (North **or** South pole).

Operating force (O.F.) — Amount of force applied to switch plunger or actuator to cause contact "snap-over." Note in the case of adjustable actuators, the force is measured from the maximum length position of the lever.

Solid State Sensors
Glossary of Terms

Operating position (O.P.) — Position of switch plunger or actuator at which point contacts snap from normal to operated position. Note that in the case of flexible or adjustable actuators, the operating position is measured from the end of the lever or its maximum length. Location of operating position measurement shown on mounting dimension drawings.

Overtravel (O.T.) — Plunger or actuator travel safely available beyond operating position.

Pretravel (P.T.) — Distance or angle traveled in moving plunger or actuator from free position to operating position.

Psychrometrics — The study of water vapor concentration in air as a function of temperature and pressure. This field of study includes numerous moisture terms and units.

Rankine Scale — A scale of absolute temperature using Fahrenheit degrees, in which the freezing point of water is 491.69° and the boiling point of water is 671.69°, measure of thermodynamic temperature.

Rated Electrical Characteristics

Supply Voltage: Range of voltage over which the sensor is guaranteed to operate within performance specifications.

Supply Current: Corresponds to current drain on the Vs terminal. Supply current is dependent upon the supply voltage.

Output Voltage: Saturation voltage (VSAT) of the output transistor. Voltage which appears at the output due to inherent voltage drop of the output transistor in the ON condition.

Output Current: Maximum output current at which the sensor is guaranteed to operate within performance specifications.

Output Leakage Current: Maximum current which remains flowing through the output transistor when it is turned OFF.

Output Switching Time: Time required by the output transistor to change from one logic state to the other after a change has been initiated. This specification applies only to conditions specified on the product drawing.

Ratiometric — The output voltage is proportional to the supply voltage in some set ratio.

Regulated Voltage — Desired output voltage is maintained regardless of normal change to input or output load.

South pole (magnetic) — The pole that is repelled by the geographical north pole, and therefore attracts the north seeking pole of a compass. Lines of flux are directed toward this pole.

Temperature calibrations — Single Point: calibration at 0°C (Ice Point); Two Point: calibration at 0°C and 100°C; Three Point: calibration at 0°C, 100°C, and 250°C.

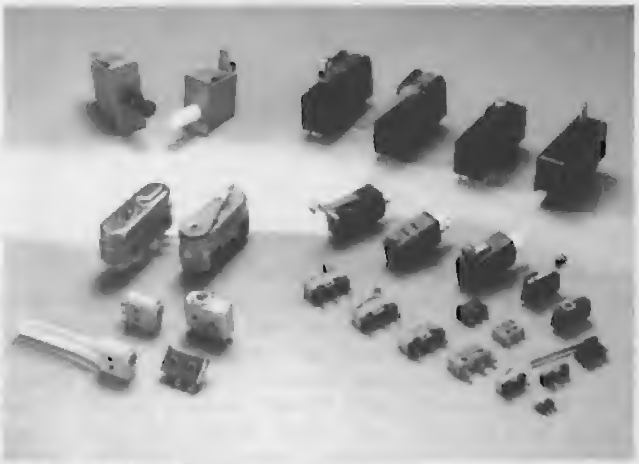
Thermodynamic Temperature Scale — Varies slightly from Fahrenheit: 211.95° vs. 212°F.

Unipolar sensor, magnetic — A Hall effect sensor that has a plus maximum operate point, and a plus minimum release point. One magnetic pole (South) is required to operate and release a unipolar sensor.

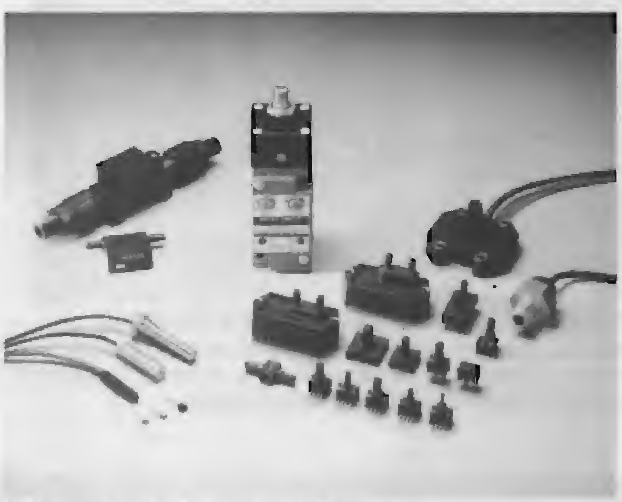
VOCs-Volatile Organic Compounds — bioeffluents (bacterial and organic compounds) found in indoor air as CO_2 levels rise.

Other MICRO SWITCH Product Catalogs

Honeywell MICRO SWITCH division's reputation as an innovator in the design and manufacture of quality position sensing and manual control products spans 40 years. Shown is a cross-section of the many varieties. This broad selection offers a wide range of technologies, sizes, actuation means, circuitries, electrical capacities, and terminations, for in-plant and original equipment needs. Contact your nearest MICRO SWITCH Sales Office or Authorized Distributor for complete catalog information. For direct assistance, contact MICRO SWITCH, Freeport, IL 61032, or phone 1-800-537-6945.



BASIC SWITCHES
These listings include standard size basics, miniature, subminiature, hermetically sealed, and high temperature switches. The precision snap-action mechanisms are offered with wide variety of actuators and operating characteristics. MICRO SWITCH basic switches are ideal for applications requiring compactness, light weight, accurate repeatability and long life. **Catalog 10.**



SOLID STATE PRESSURE SENSORS
MICRO SWITCH pressure sensors are small, low cost and reliable. They feature excellent repeatability, high accuracy, and reliability under varying environmental conditions. In addition, they feature highly consistent operating characteristics from one sensor to the next and interchangeability without recalibration.

MICRO SWITCH offers four pressure sensor measurement types—absolute, differential, gage, and vacuum gage and pressure ranges from $\pm 5''H_2O$ to 250 psi. **Catalog 15.**

INFRARED PRODUCTS
Optoelectronics is the integration of optical principles and semiconductor electronics. Optoelectronic components are reliable, cost effective sensors. Standard infrared emitting diodes (IREDs), sensors and assemblies are covered. **Catalog E26.**

FIBER OPTIC LAN PRODUCTS
The Fiber Optics group specializes in the design, development and manufacture of active optoelectronic components and subassemblies for the short-haul fiber optic datacom market. Active fiber optic products are compatible with the majority of standard multimode fiber optic connectors and cables now available in industry.

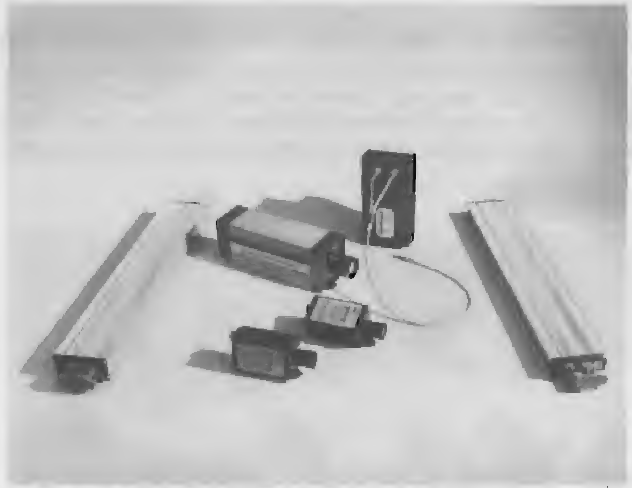
Custom fiber optic products are also available. They are standard products with special testing, selection, documentation and/or minor physical changes to meet special requirements. New innovative products are constantly in development. **Catalog 27.**

Other MICRO SWITCH products

LIMIT AND ENCLOSED SWITCHES
MICRO SWITCH offers the world's most advanced line of heavy duty limit switches and a wide selection of application proven enclosed switches (precision snap-acting switches sealed in rugged metal housing). Sealed versions keep out moisture and other contaminants. Explosion-proof types are designed for use in hazardous locations. **Industrial Catalog.**

PROXIMITY SENSORS
Proximity sensors detect the presence of metals or react to a magnetic field. Cylindrical, cannister, and limit switch style housings provide application versatility. Their high speed operation keeps pace with production. Models are available for operation at AC line voltage or wide range VDC. Optional LED indicators signal on-off conditions. **Industrial Catalog.**

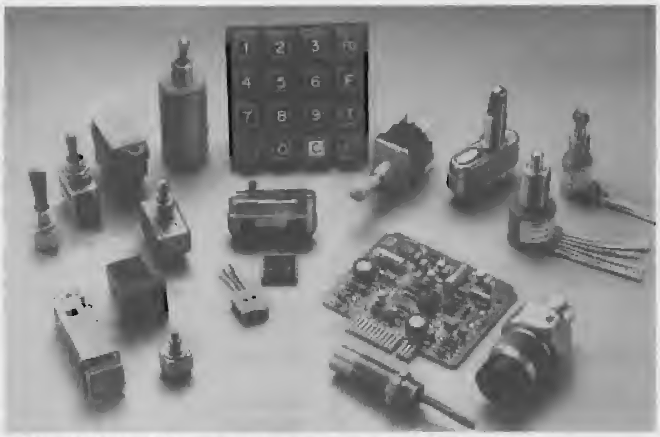
PHOTOELECTRIC SENSORS
MICRO SWITCH has a complete offering of modulated LED and incandescent controls. These devices detect opaque or translucent material at long or short range. Single unit retroreflective and separate emitter/receiver styles fill a variety of application requirements. High intensity models penetrate foggy, dusty, and other poor visibility conditions. Scanning capability ranges from a fraction of an inch to hundreds of feet.
Industrial Catalog.



LINE ARRAY/COLOR/SAFETY SENSORS
Precision edge/width sensors meet exacting requirements for precision, high-speed position and distance measurement. Object recognition sensors scan parts and compare their images with reference images preset in sensor memory. Color sensors can be trained to recognize 8 different colors or shades – online – at up to 5000 parts per minute. Safety light curtains are machine guarding devices which meet OSHA and ANSI, as well as many European certifications. **Industrial Catalog.**

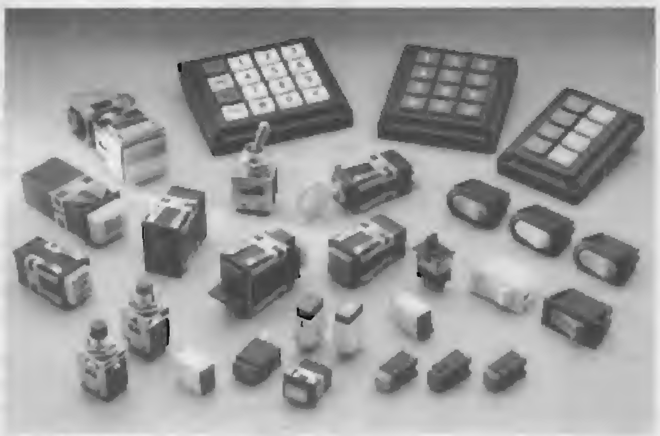
ULTRASONIC PRECISION PROXIMITY SENSORS
Ultrasonic position sensors solve tough sensing problems, detecting targets made of practically any material. They work in dry, dusty environments. **Industrial Catalog.**

Other MICRO SWITCH products



ENVIRONMENTALLY PROTECTED SWITCHES

Rugged, high performance designs; environment-proof or hermetically sealed. A complete selection includes miniature limit switches, miniature and standard size basic switches, sealed, toggle switches and the highest quality lighted pushbuttons. **Catalog 80.**



MANUAL CONTROL SWITCHES

Whether you're prototyping a new design or planning to face-lift an existing panel, you'll benefit by considering the wide selection of pushbuttons, indicators, toggles, rockers, paddles, rotary selectors and interlock switches available from MICRO SWITCH. Developed with adherence to good human factors principles, these products aid the designer by offering almost limitless options in visual display techniques, operators, and arrangement of components. Many are military qualified. **Catalog 30.**

MULTI-LIGHT OILTIGHT CONTROLS

Featuring the contemporary square appearance and lighted display, the CMC family offers a wide selection of industrial pushbuttons, selectors and indicators. Contact blocks include heavy duty, standard or electronic duty, plus the four plunger adapter kit to use all four points on the cam. **Multi-light Oiltight Controls Catalog.**

SMART DISTRIBUTED SYSTEM

The Smart Distributed System is a bus system for intelligent sensors and actuators that streamlines the system installation process and empowers your inputs and outputs to operate at levels you never though possible. Over a single 4-wire cable, Smart Distributed System can interface up to 126 individually addressable devices. These intelligent sensor and actuator devices do much, much more than just turn on and off.

SYSTEM DIAGNOSTICS

The Smart Distributed System is based on the CAN Protocol. CAN is a full function network protocol that provides both message checking and correction to insure communication integrity.

DEVICE DIAGNOSTICS

Many of the Smart Distributed System devices have special diagnostics designed into them. For instance, some of the photoelectric controls can send warning messages if their lenses get dirty or they are out of alignment. Other diagnostics will be coming in the future.

DEVICE FUNCTIONS

All Smart Distributed System devices are intelligent and can be setup, via the Activator or PC base control programs, to perform high-level functions that non-System devices simply cannot do. Using the System device functions you can off-load rudimentary control functions to the devices, allowing the host to concentrate on errors if they occur. Smart Distributed System device functions include:

- Normally-open or normally-closed (switches and sensors)
- Light operate or dark operate (photoelectric controls)
- On-delay
- Off-delay
- Motion or jam detection
- Batch counter
- Number of operations count
- Number of power cycles count

TRULY OPEN DISTRIBUTED MACHINE CONTROL

The Smart Distributed System is uniquely and completely open. It works with the PLC or PC control device of your choice. That makes the Smart Distributed System completely compatible with your present control system or whatever control system you have in mind for the future. In fact, no other distributed machine control system offers as much flexibility or growth potential. The Smart Distributed System protocol will even accommodate peer-to-peer communication.

MORE DEVICE SELECTION FOR GREATER FLEXIBILITY

Many manufacturers of industrial control devices have become part of Smart Distributed System simply by integrating our CAN-based chips or by utilizing off-the-shelf interface devices. The Smart Distributed System can be easily integrated into your control system, allowing you to choose the equipment and manufacturers that best match your application.

Alphabetical Product / Page Cross Reference Index

Honeywell Global Sales and Service

As a division of Honeywell, we serve our customers through a worldwide network of sales offices and distributors. For application assistance, current specifications, pricing or name of nearest Authorized Distributor, contact one of the offices listed below. Or, contact us at our headquarters: MICRO SWITCH, Honeywell Inc., Freeport, Illinois 61032, USA.
Email: info@micro.honeywell.com

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Printed with Soy Ink
on 50% Recycled Paper

005657-17-EN IL50 GLO 1097 Printed in USA